

NO.27 FEBRUARY 1997

SUPPLEMENT

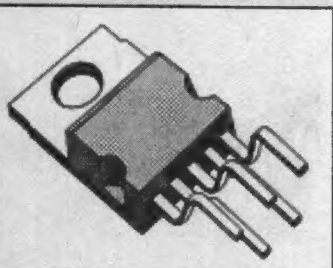
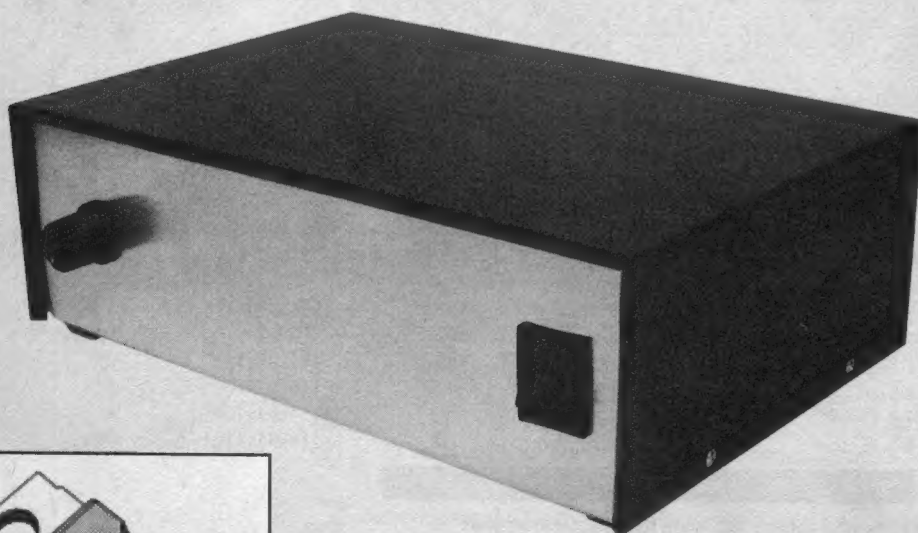
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**BOOK REVIEWS:**

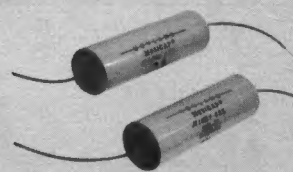
**ACOUSTICS AND  
PSYCHOACOUSTICS**  
by Howard & Angus

**AUDIO POWER AMP.  
DESIGN HANDBOOK**  
by Douglas Self

**Audio Power  
Amplifier Design  
Handbook**  
DOUGLAS SELF



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WITH  
SPECIAL  
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2A3	34	6A3	32	6B4G	32	4300B	68	211	85	305	66
KT66	68	KT88	86	8550C	22	807	8	311	18	312	28
813	28	815	22	808	30	12E1	14	1LE12	36	1SE1	90
8L8G	12	7581A	15	7504	38	DA41	14	DA12	14	DA100	675
PX4	86	PX25	130	PT25	150	CV4060	38	CV6045	90	V1505	700
PRE-AMP Tubes	£ Each	PRE-AMP Tubes	£ Each	PRE-AMP Tubes	£ Each	PRE-AMP Tubes	£ Each	PRE-AMP Tubes	£ Each	PRE-AMP Tubes	£ Each
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E98CC	12	A2900	28	BJ5GT	5	BSN7GT	6	BSU7GT	12	ECC32	20
ECC33	20	ECC34	18	ECC35	18	M8137	22	CV4003	12	CV4004	14
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GZ34	14	G737	7	EX80	2	EZ81	5	EX90	2	866A	20

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0.01 µf	600	£1.35	0.001 µf	1000	£0.58	68 pf	500	£1.63	16+16 µf	450	£7.10
0.02 µf	600	£1.49	0.002 µf	1000	£0.64	120 pf	500	£1.78	50+50 µf	400	£10.62
0.05 µf	600	£1.68	0.006 µf	1000	£0.77	220 pf	500	£1.88	220 µf	400	£18.40
0.1 µf	600	£2.17	1.0 µf	600	£2.18	470 pf	500	£2.10	470 µf	400	£20.18
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Note

Note! This Capacitor comes in Aluminium Can only. Dic 65 m/m Len 95 m/m. This Capacitor is of superior quality to anything else available and has been designed by us for use in Tube Power Supplies.

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Transformers! Output transformers are Hand Wound using the Very best quality OFC, Silicon steel and Silver wire lead outs. Shroud are supplied in Black Crackle paint finish upright of drop through mounting. Or special order Chrome, Copper, plated. (Please call for a quote) P/P push pull, SE. single ended.

Tube	Impedance	Taps	Sec Ohms	DC m/2	Watts	Type	Dimensions	Price £ Each
300B	2K5		4-6-16	90	8	SE	114x95x110	105
211/VT4C	9K2		4-8-18	60	20	SE	114x95x135	128
845	11K		4-8-16	80	30	SE	114x95x135	144
KT66	4K5		4-8-16	68	5.8	SE	114x95x100	95
KT88	5K	40%	4-8-16	90	50	P/P	114x95x110	108

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All chassis are made from solid copper 2m/m thick with welded corners and 5m/m flange for bottom plate

Sizes	L	D	H	Price £ each	L	D	H	Price £ each	L	D	H	Price £ each	L	D	H	Price £ each
	330x	200x	75	98	400x	250x	75	128	450x	350x	85	180	600x	300x	100	212

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We have re-printed the famous Langford-Smith Radio Designers Handbook 4th edition. We have only a few copies at £80 per 2 volume set. Bound in black imitation leather gold block A4 size, weight 4.8 kilo's. Only 18 copies left.

## TERMS OF TRADE

All prices quoted are FOB UK. Delivery on some items is 10 to 14 days. Payment can be made by credit card, Cheque, or Telegraphic Transfer. Tubes are warranted as working 100% but not there visual appearance. Minimum order value £100, all prices quoted exclude delivery and VAT at the prevailing rate.



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Audio Publishing Ltd and World Audio Design Ltd accept no responsibility for accident or injury arising from the construction or use of any of the designs published. All of the projects in this supplement have gone through rigorous listening and test procedures. The performance and specification of these projects can only be guaranteed on kits bought directly from World Audio Design Ltd.

## KIT NEWS

From transformers to tweeters, you'll find some rare but valuable hi-fi bits in this section.

5

## 30 watt SILICON CHIP AMPLIFIER

This has got to be the greatest way to build your first amplifier. Dead simple but very effective. Great for beginners, the impoverished, students and audio addicts everywhere.

7

## TUNING WITH SPECIAL COMPONENTS

Whatsa Black Gate? You mean to tell us you don't know? It's somfing black sheep go through. If you believe this, then you need to read this feature to protect your audio cred. Or jump off a cliff in shame.

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## BOOK REVIEW:

### ACOUSTICS AND PSYCHOACOUSTICS

by Howard and Angus

A goodly sized tome covering sound, room acoustics, human hearing mechanisms and perceptual strategies, plus electronic sound processing. Reviewed by Noel Keywood.

21

### AUDIO POWER AMPLIFIER DESIGN HANDBOOK

By controversial but experienced designer Douglas Self, this book is backed by solid practical experience, available research and Self's interest in producing the 'perfect' amplifier. Reviewed by another designer of great experience and knowledge, Andy Grove.

23

## DIY QUERIES

Loads-a-Queries from our DIY swagbag. This is where the discussions are technical, esoteric - and interesting! Yes, lots of in-depth info on what makes a good hi-fi design.

25

# WATFORD VALVES

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**RESTORATION.** Messrs, Leak, Walker, Radford *et al.* got it right! Yesteryear's great designs are, in the main, fine. They certainly don't need converting into something else, which seems to be a current trend. We will carefully restore your classic using modern high-quality components; this alone frequently improves the sound quality enormously. We will not, though, alter the original design in an attempt to "improve" it. Enjoy owning and listening to a Classic... not a latterday fad.

**REPAIR/CALIBRATION.** Even the finest equipment's will suffer an occasional breakdown and need meticulous repair, calibration and alignment. The **only** standards we recognise and work to are Manufacturers Original. Our Test & Measurement facilities are probably the best in this sector of the Industry... and we know how to use them!

**KIT-BUILDING.** There are numerous kits around nowadays. They all require skill/experience to build satisfactorily and, in the case of valve equipment, safely. Some designs are good, others ....well, let's just say their 'designers' would benefit from a sojourn on that celebrated desert island with only Terman and Langford-Smith for company!

**Whichever kit you choose, though, it will benefit from a professional build.** We will build it, de-bug it and give you a set of Final Test figures from your sample.

**KIT-RESCUE.** In trouble? It won't work? *Nil desperandum.* Contact us about a rescue/re-furbish.

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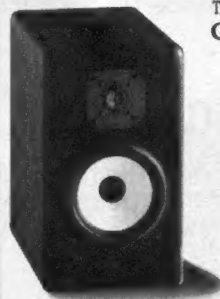
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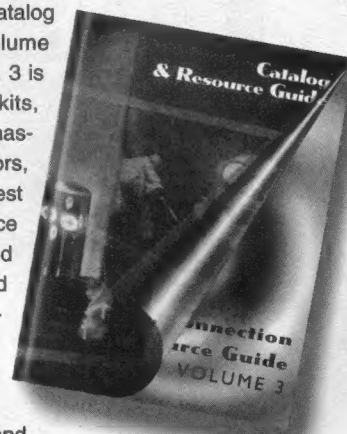
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## It's Here!!

The new Parts Connection Catalog and Resource Guide, Volume

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# KIT NEWS

## MISSING LINK

The latest audiophile catalogue from Audio-Links of Scunthorpe is now available. Priced at £2, it contains high quality resistors (running from Vishay bulk foils through to Holco's 0.5% H8 series), capacitors (Ansar Supersound and Silversound, Hovland Musicaps, Elna Cerafines and Panasonic Os-cons) and potentiometers (Alps Blue and Black Beauty as well as Panasonic).

There's also a range of switches, connectors (including gold-plated cartridge tags) and interconnects in addition to loudspeaker and mains cables. The bullion brigade get a look in with pure silver wire, from 36gauge to 14gauge, and matching silver-loaded solder.

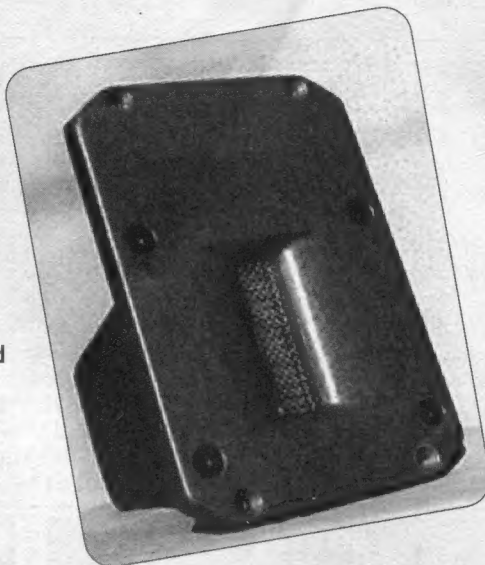


Transistor fans will be happy to find Schottky and soft-recovery diodes, voltage regulators and low noise toroidal transformers as well.

**Audio-Links**  
7 Fairmont Cresc.,  
Scunthorpe,  
North Lincs.  
DN16 1EL  
Tel: 01724 870432

## RIBBON SINGS THE HIGHS

If dome tweeters fail to bring a smile to your face and ribbon tweeters are more your cup of tea, there's now one more to choose from with the arrival of the HRL-1s from Howard Dawson Audio. These are built around powerful ALCOMAX-3 magnets and an extremely



lightweight ribbon to maximise the driver's efficiency (90dB), speed and accuracy.

Given the fact that a pair of HRL-1s will set you back £300, replacing the ribbon element itself is reassuringly cheap (£10) and easy - owners can even make new ribbons themselves, according to Howard Dawson. And almost any impedance can be specified because the HRL-1's matching transformers are interchangeable.

**Howard Dawson Audio**  
16 Copeman Road,  
Aylsham,  
Norwich NR11 6JL

## ITALIAN TRANSFORMATION

If you're having a hard time making up your mind as to what output transformer to buy for that killer valve amp you've been slaving over, Bartolucci can help you out. This Italian company offers over 60 different output transformers to suit a range of valves. Power handling is between 10W and 50W for transformers aimed at single-ended amps, while push-pull versions run from 8W up to a healthy 140W.

All the above transformers are multiple section, multiple layer designs, hand-wound for accurate interleaving and correct wire tension. They come potted with micro-crystalline wax in a hand-made steel enclosure, with output taps that allow matching to 'speakers of

4, 8 and 16 ohms impedance.

Further broadening Bartolucci's brochure is a step-up transformer for MC cartridges as well as interstage coupling and pre-amp output transformers.

Helping out in the power supply department is a range of chokes, running from 10H at 400mA up to 150H at 50mA.

**Audio Marketing**  
Via del Meridiano 38,  
Domagnano,  
47031 San Marino  
Tel: (378) 906634

## WHAT, MORE TRANSFORMERS?

SJS Electroacoustics are expanding their transformer goodie bag and now offer five interstage transformers (with prices from £149 to £189/pr) to complement their pre and power output transformers. Fans of single-ended will be happy to see



they're offered not only the Standard and Super range (with its superior windings) but also five 'state of the art' transformers. These all employ very complex winding techniques and high purity Oxygen Free Copper with PTFE-insulated, pure silver flying leads, and are potted in non-magnetic cases.

Occupying the catalogue's other pages are power supply chokes and capacitors (custom polypropylenes, Black Gates, Mallorys, Spragues and Hovland Musicaps), Holco H2 1W 1% resistors and silver cable.

**SJS Electroacoustics**  
Ben-Dor,  
Lumb Carr Road,  
Holcombe,  
Lancs. BL8 4NN  
Tel: 01706 823025

$\alpha$ 

Billington Gold

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Long known as specialists in rare tube brands, Billington Export provides a line of premium-grade valves to fill the increasing demand for hard-to-find tubes! BILLINGTON GOLD features specially tested valves selected for long life, low microphony and low noise. Versions with gold plated pins are available. BILLINGTON GOLD brand comes from a variety of countries around the world. We have carefully chosen the best manufacturer for each type, with an

emphasis on the highest audio quality and product reliability. We stock one million valves including: BRIMAR, GE USA, GEC UK, MAZDA, MULLARD, RCA, RUSSIAN/SOVTEK/SVETLANA, SYLVANIA, TESLA, THERMIONIC, TUNGSRAM and other rare brands, as well as sockets and CRTs.

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ECC83	5.25
ECC88	4.50
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EL84	3.60
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KT88	18.50

**RARE BRANDS**

5R4GY RCA	POA	6550A GE USA	42.00
5Y3GT RCA	2.90	CV4004 Brimar UK	POA
6BH6 RCA	2.48	DG7-32 Tungstram Hungary	21.00
6CG7 Yugoslavian	6.75	ECC81 Mullard UK (CV4024)	7.50
6V6GT STC UK	5.93	ECC82 Mullard UK (CV4003)	POA
6X4W Raytheon USA	3.00	ECC83/ECC803S Tesla	13.13
6336A	66.00	ECC83 Yugoslavian	2.93
12BH7 Yugoslavian	6.90	ECC85 Tungstram	3.45
12BH7A GE	15.00	ECC86 Tungstram	3.45
12E1 STC/ITT UK	15.00	EF86 GEC UK (CV4085)	19.50
13E1 STC UK	120.00	GZ32 Mazda	9.00
85A2 Mullard	4.50	GZ37/CV378 Mullard UK	5.93
807 USA	8.20	KT90 Yugoslavian	24.00
5687 Sylvania	6.45	PL519 Tungstram	8.40

**SOVTEK**

5U4G	3.60	ECC83/12AX7WB	3.75
6L6WGC	6.30	EF86	POA
6SL7GT	2.50	EL34G	6.20
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ECC86 Mullard	2.93
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GZ34 Chinese	7.40
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Jumbo 4-Pin for 211, 845, etc	10.50
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UX5 McMurdo UK for 807	3.60
B7A for 6C33CB	3.23
B7G McMurdo UK, chassis, skirted	0.72
813 ceramic	7.50
Octal McMurdo UK	1.20
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B9A PCB, gold pins	1.88
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TOPCAP for 12E1, 5B-254M, PL519	2.93
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We manufacture sockets in the UK for use with DA100, 4212E, F2A, EL156, ML4, PX25, etc. Please ask for our catalogue for full details.

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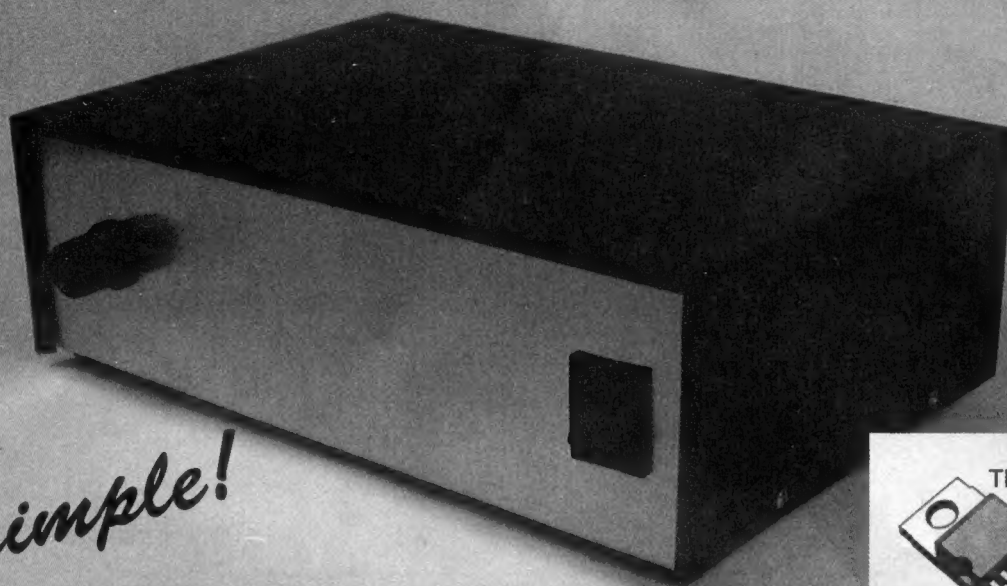


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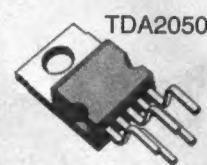
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# YOUR FIRST DIY AMPLIFIER



*It's simple!*



**Want to build your first amplifier? The simplest way is to use a dedicated silicon chip. The components shouldn't amount to more than £60 and there are no naughty voltages. Chris Found explains, step-by-step.**

**T**V set manufacturers are just one example of those who use one-piece amplifiers on a silicon chip. There are plenty to choose from. These amplifier modules are not in the High End league but they certainly fulfill basic requirements well, giving lots of Watts per Pound.

For a student with very little money or someone who is just starting a course in electronics and needs to gather firsthand knowledge of building, these units are an ideal starting point. To build the units presented in these articles you need to be able to solder components to a board and want to do something you might never have done before.

When I looked at the data sheets, today's sophisticated chip amps look like an amazing bargain. We chose one that is easy to obtain, has been honed through useage and is, technically, easy to understand as well. It is the

SGS Thomson TDA2050. A stereo amp. needs two of them, amounting to no more than £12. However, the mains transformer can cost up to £15, electrolytic capacitors £8 or so and a chassis / heatsink any price you choose. So it's impossible to put an exact price on this amp, but £60 should do it easily.

## The SGS-THOMSON

words a T0220 transistor with five legs instead of three. Bear the package type in mind when selecting a heatsink.

It is capable of working on single or simple split rail power supplies. The split rail supply option is especially useful because it eliminates the output coupling capacitor, and its degradation of sound quality.

The 2050 can produce

rail of +/- 22V.

You might feel that 10% distortion is just a tad excessive, but it is merely a way of defining overload and maximum output. For most music applications such as an audio stage in a TV set, the distortion will be substantially lower than this, as our measured performance figures show. Performance is very good indeed for its low price and this chip is both robust and reliable - almost bombproof in fact.

Sophisticated circuit protection has been applied, as well as thermal limiting. This makes the TDA2050 an extremely reliable product for any manufacturer, but also for the DIYer.

Looking at the 2050's operational schematic diagram (Fig 1, p8) shows just how simple the unit is to construct. Just eight components per channel are needed, plus decoupling and power supply components. Providing you are careful



**SGS-THOMSON**  
**MICROELECTRONICS**

**TDA2050**

32W HI-FI AUDIO POWER AMPLIFIER

- HIGH OUTPUT POWER (50W MUSIC POWER IEC 268.3 RULES)
- HIGH OPERATING SUPPLY VOLTAGE (50V)
- SINGLE OR SPLIT SUPPLY OPERATIONS
- VERY LOW DISTORTION
- SHORT CIRCUIT PROTECTION (OUT TO GND)
- THERMAL SHUTDOWN



The TDA 2050 is a monolithic integrated circuit in Pentawatt package, intended for use as an audio class AB audio amplifier. Thanks to its high power capability the TDA2050 is able to provide up to 35W true rms power into 4 ohm load and up to 32W into an 8ohm load.

## TDA2050

The TDA2050 is an Integrated Power I.C. built into what is normally called a Pentawatt package, in other

some 35watts into a 4Ω load (the limit being defined by 10% distortion) when using a supply of +/-18volts, or 32watts into 8Ω with a supply

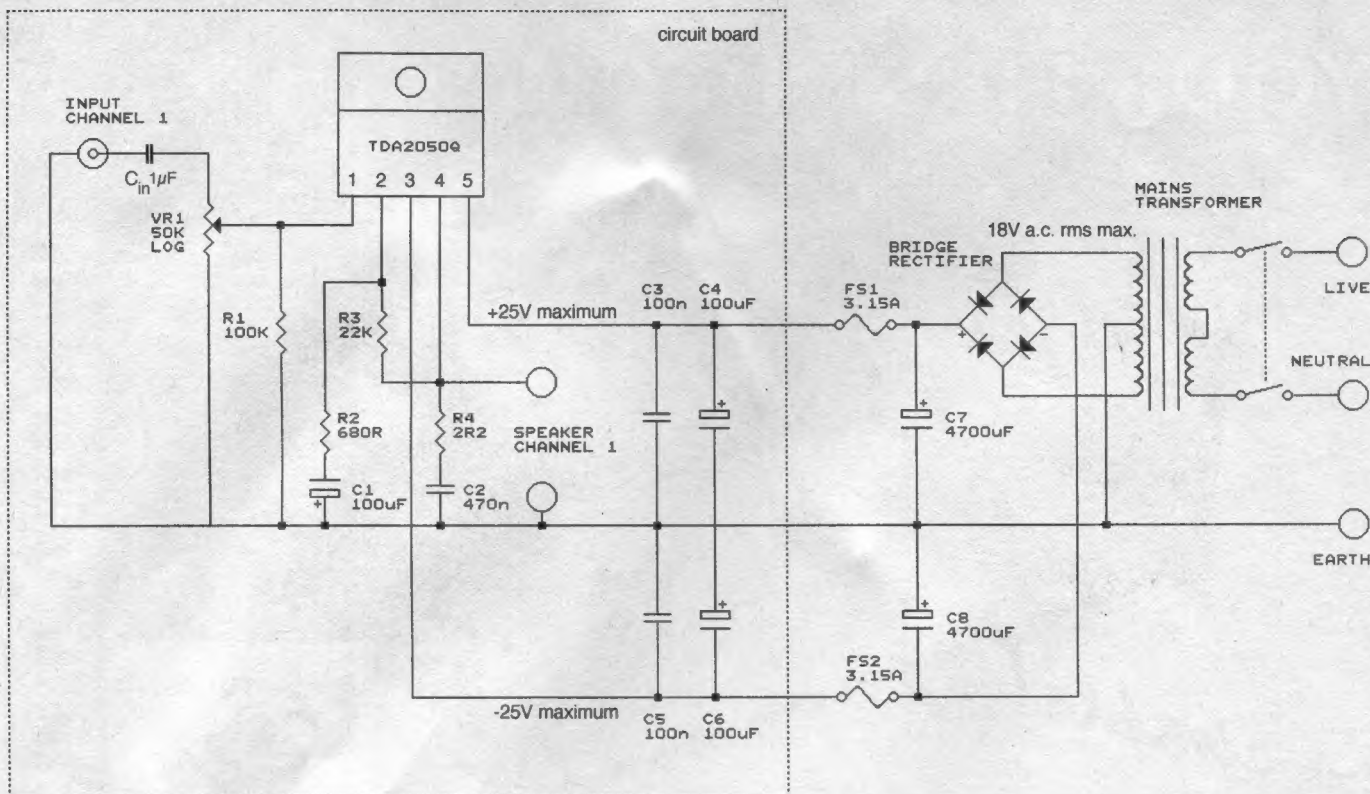


Fig 1 - Schematic of circuit

### How the circuit works.....

The signal is fed in through  $C_{in}$ , which acts as a d.c. blocking capacitor. This should be left in for safety, since residual d.c. exists on many sources. Remove it if working from a preamp with an output blocking capacitor. Feeding d.c. in will otherwise produce d.c. on the output, which will offset the 'speaker cones.

$R1$  holds the non-inverting (+) input to ground with respect to d.c. conditions, should the volume control fail to do so.  $C1/VR1$  form a high pass filter with a -3dB point around 4Hz. Lower  $C_{in}$  to 0.47µF and this rises to around 8Hz, which is where most designers choose to put the lower limit.

Feedback, both a.c. and d.c., is applied from output back to the inverting (-) input through resistor  $R3$ , set at 22k. Altering this resistor changes the amount of feedback applied,  $R3/R2$  acting as a potential divider with respect to the a.c. (audio) signal being fed back. Reducing  $R3$  increases the amount of feedback applied. This will increase bandwidth, decrease distortion and reduce gain. Go too far and the circuit will oscillate (i.e. become unstable). Increasing  $R3$  will improve stability and raise gain, but increase distortion and lower bandwidth. Capacitor  $C2$  ensures 100% d.c. feedback is applied. Ideally, this capacitor should comprise two back-to-back tantalums of 50µF-200µF, in order to produce a non-polarised capacitor.

Components  $R4$  and  $C2$  ensure high frequency stability. Capacitors  $C3$  and  $C5$  ensure power line decoupling is effective at high frequencies. These should be good quality polypropylenes. The chip has both short circuit protection and thermal shut down, so it's rugged.

The chip is designed to accept 25V maximum on its supply rails. We recommend using a mains transformer of 15V a.c. rms, but an 18V a.c. transformer can be used, which will give 23V-24V, taking into account regulation, bridge rectifier losses, etc. A rating of 50VA minimum should be used. Bigger VA ratings give better regulation and stronger bass. Chris Found lists Maplin's DH63T, which has two 15V secondaries, one 240V primary, is rated at 4A and 120VA and costs £18. Cricklewood Electronics (0181-450-0995, 40 Cricklewood Broadway, London NW2 3ET) is where we bought our parts and they can help too. NK

(more so, if you are a first time builder), you should be able to get this unit up and running in no time at all.

I decided to build the prototype amplifier on two separate pieces of 0.1" copper clad Veroboard. It allows the amplifier to be built in easy stages, replacement of one part is made easier, servicing is easier and Veroboard is best when circuits are kept small and simple. Large Veroboard constructions are prone to

problematic mix-ups. Our Veroboard layout is very simple and providing basic procedures are adhered to, the units should work straight away.

#### FIRST TIME

The following list should be used when constructing anything for the first time. It safeguards not only your hard earned money but also ensures that you do not die in the attempt of building your first unit.

Build each board slowly and follow the drawings very carefully, checking every solder joint, component position and the polarity of the components. If necessary redraw the layout on a separate sheet with all the positions and their polarities.

Where mains voltages are concerned, use sleeved 'crimp on' spade terminals for the mains switch and the IEC mains connector. You can get these from any car spares shop and they are very cheap.

Also use only the appropriate wire suitable for the job in hand. Do not use wire too thin for the mains linking, as this could overheat and cause a fire if left on for an appreciable amount of time.

Triple check everything in accordance to the information given. If you are unsure, ask a local repair shop or a knowledgeable friend to look over the unit. It may cost you a few quid but it's worth it.

Make a final check against



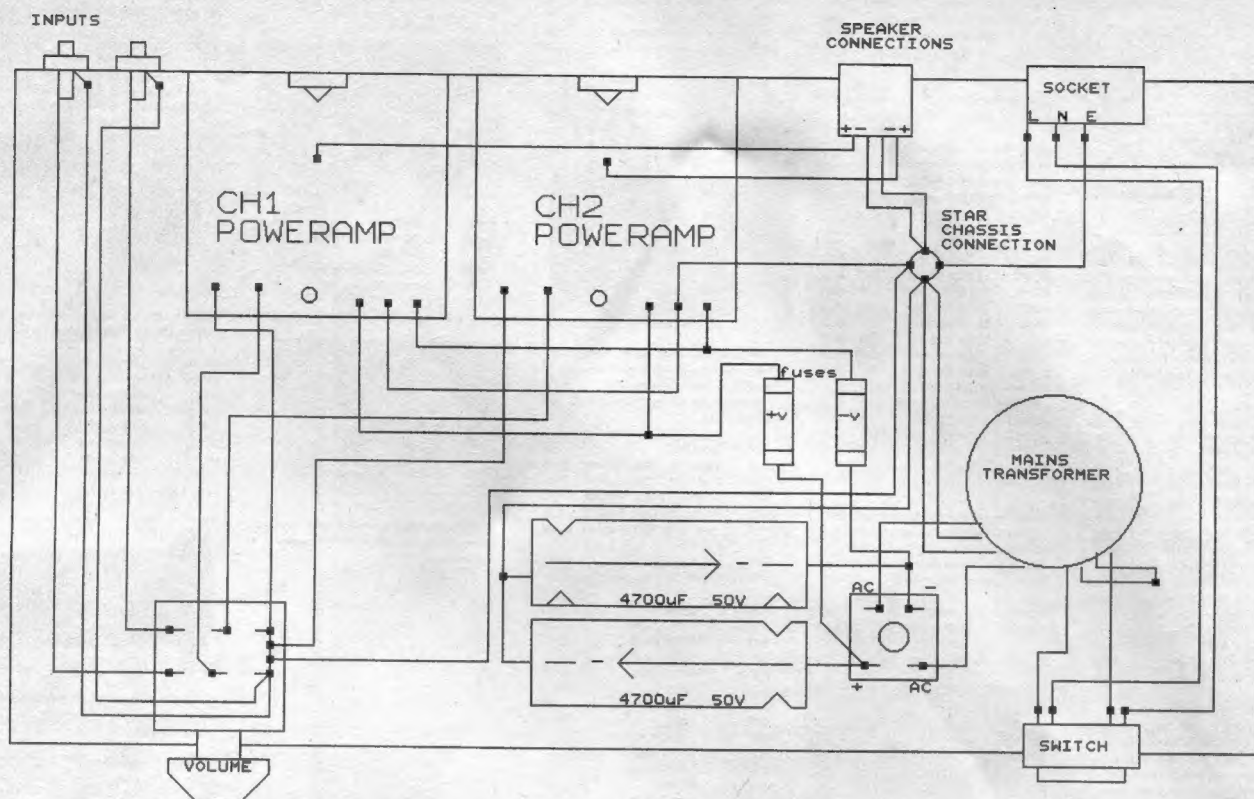


Fig 2 - Amplifier layout

all of the drawings, ensuring the areas that require isolation, i.e. the heat sink and the tab on the devices, are electrically isolated from the chassis but thermally connected using the proper heat sink compound, thereby allowing heat to be dissipated effectively.

When you power up the unit for the first time, do not

mind that the large reservoir capacitors used need time to discharge.

*Always remember, anything connected to the Mains supply is potentially dangerous.*

**MAINS VOLTAGES CAN KILL.** Use extreme care and follow all instructions to the letter.

*If you have a multimeter check the various test points for their*

iron, not the Weller Arc welding type Spanners if you can borrow some

## CONSTRUCTION

Cut a small piece of Veroboard 17 strips wide and 17 holes long and clean off the rough edges with a small flat file. Fig. 3 shows the placement of the components

for each of the two pieces of Veroboard. You will notice that these two boards are identical. The remaining power supply components are hardwired. Each piece of Veroboard comes pre-drilled as standard with copper tracking strips to allow components to be placed in certain positions. I normally remove all the unwanted tracking to prevent shorts when soldering and put Vero terminal pins in the positions that require wire to be soldered to the boards.

On each of the two amplifier boards the TDA2050 is mounted as close to the far end of the board as possible, track side down. The TDA2050 chip connection pins go through

the opposite side of the board. The metal tab of the 2050 is secured to the inside wall of the case and the optional outside heat sink.

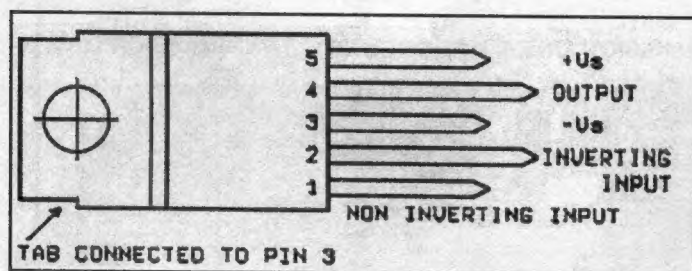
To ensure the board stays rigid and cannot short to the metal case a plastic spacer is mounted at the opposite end to provide support. It helps when wiring up the boards later.

Construction of the power supply section is very simple. I used a large chassis-mounting bridge rectifier, which is marked on its body +, -, AC, AC.

## WIRING THE POWER SUPPLY

First, mount the bridge rectifier to the case using an M3 screw and nut. Next, connect the spade connectors to the secondary wires of the mains transformer then push them onto the AC terminals of the bridge rectifier. They go on either way around; there is no polarity to be observed.

Fix the reservoir capacitors to the chassis, either with a clamp or using glue. Solder the positive wire of one reservoir capacitor to



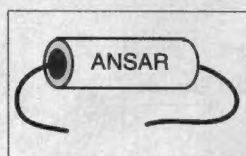
connect any speakers to the output terminals. Do not connect an input signal either. Instead very carefully look and smell for burning, but do not get too close just in case there is something wrong. Wear some protection for your eyes if you need to look closer than a few feet. Leave on for only two minutes and then switch off and leave the unit to cool down for at least 15 minutes. Please bear in

mind that the large reservoir capacitors used need time to discharge.

## TOOLS

The following tools are required to build the amplifier. Small wire cutters Small and medium size pliers Various screwdrivers Files Electric or Hand drill with assorted drill bits 15 or 25W small soldering

The secret's in the metallised film!



Manufactured specifically for high end audio, these polypropylene capacitors offer exceptional value for money as they use a specially imported high purity metallised polypropylene film, ensuring smooth, detailed and transparent sound quality and extremely low distortion, whether they are placed directly in the signal path such as in crossovers or for decoupling etc. Ideal for replacing old, stale and leaky capacitors.

Part No.	Value	Price
CW100N	CAP PROPYL 1000F	£1.25
CW150N	CAP PROPYL 1500F	£1.25
CW220N	CAP PROPYL 2200F	£1.25
CW330N	CAP PROPYL 3300F	£1.25
CW470N	CAP PROPYL 4700F	£1.25
CW680N	CAP PROPYL 6800F	£1.25
CW100N	CAP PROPYL 1µF	£1.25
CW150N	CAP PROPYL 1.5µF	£1.50
CW220N	CAP PROPYL 2.2µF	£1.50
CW330N	CAP PROPYL 3.3µF	£1.85
CW470N	CAP PROPYL 4.7µF	£2.00
CW680N	CAP PROPYL 6.8µF	£2.50
CW100N	CAP PROPYL 10µF	£3.50
CW150N	CAP PROPYL 15µF	£4.50
CW220N	CAP PROPYL 22µF	£6.50
CW330N	CAP PROPYL 33µF	£9.95
CW470N	CAP PROPYL 47µF	£10.00

Low value capacitors are extensively used in amps & preamps (especially in tone control, bass & treble etc). By changing to polypropylene you can enjoy an enhanced lighter - brighter sound especially in the treble and mid bass range, and a transparent lower bass improvement. Close tolerance & high stability ensure that both channels can be very closely matched.

Part No.	Value	Price
CP477P	CAP PROPYL 47µF	£0.35
CP100P	CAP PROPYL 100µF	£0.35
CP150P	CAP PROPYL 150µF	£0.35
CP220P	CAP PROPYL 220µF	£0.35
CP330P	CAP PROPYL 330µF	£0.35
CP470P	CAP PROPYL 470µF	£0.35
CP100N	CAP PROPYL 1µF	£0.35
CP150N	CAP PROPYL 1.5µF	£0.35

CP220N	CAP PROPYL 2.2µF	£0.35
CP477P	CAP PROPYL 47µF	£0.35
CP100N	CAP PROPYL 100µF	£0.35
CP220N	CAP PROPYL 22µF	£0.35
CP477P	CAP PROPYL 47µF	£0.35

Low Impedance High Temperature  
(105° C) Radial Electrolytics ± 5%

Superior electrolytics at affordable prices. The low impedance and resistance maximises signal purity, whilst the superior temperature characteristics allow the capacitor to remain very stable under the most varying conditions.

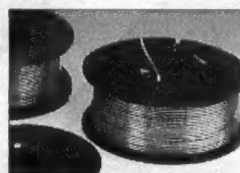
Part No.	Value	Voltage	Price
1H50	LO 2 H TEMP 1µF	50V	£0.25
2U2H50	LO 2 H TEMP 2.2µF	50V	£0.25
4U7H53	LO 2 H TEMP 4.7µF	63V	£0.25
10K63	LO 2 H TEMP 10µF	63V	£0.25
22H63	LO 2 H TEMP 22µF	63V	£0.30
47H63	LO 2 H TEMP 47µF	63V	£0.35
100H63	LO 2 H TEMP 100µF	63V	£0.50
220H50	LO 2 H TEMP 220µF	50V	£0.75
470H53	LO 2 H TEMP 470µF	63V	£1.25
1000H35	LO 2 H TEMP 1000µF	35V	£1.50
2200H50	LO 2 H TEMP 2200µF	50V	£2.25
4700H25	LO 2 H TEMP 4700µF	25V	£2.50

Elna Solder Lug Reservoir  
Capacitor 10,000µF 80V

Choosing the right electrolytic for power supply use is very important in keeping down hum whilst allowing maximum current flow for good transient & bass response. Elna capacitors are respected the World over for their exceptional audio attributes.

Part No.	Value	Price
10000C80	CAL ELNA 1000µF/80V	£11.00

Monacor Air Cored Inductors.

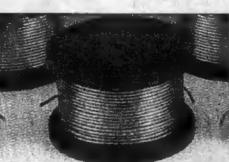


A range of professional air cored inductors for 8Ω or 4Ω crossovers/filters for use up to 300W. 1.2mm enamelled copper wire wound on air spaced plastic bobbins.

Part No.	Specification	Price
P15	150µH 0.15Ω 8x19mm	£2.00

P22	220µH 0.15Ω 48x19mm	£2.50
P33	330µH 0.2Ω 8x19mm	£3.00
P47	470µH 0.25Ω 50x19mm	£3.50
P68	680µH 0.35Ω 59x19mm	£4.50
P100	1mH 0.4Ω 59x19mm	£5.50
P150	1.5mH 0.5Ω 70x30mm	£6.50
P220	2.2mH 0.6Ω 70x30mm	£8.00
P330	3.3mH 0.75Ω 70x30mm	£10.00

Monacor Ferrite Inductors



A range of professional high efficiency ferrite cored inductors with very low ohmic losses for 8Ω or 4Ω crossovers or filters for use up to 400W. 1.4mm enamelled copper wire (1.3mm on F1000) wound on plastic bobbins.

Part No.	Specification	Price
F220	2.2mH 0.15Ω 400W 55x31mm	£6.50
F330	3.3mH 0.2Ω 330W 65x39mm	£9.50
F470	4.7mH 0.25Ω 140W 65x39mm	£11.00
F680	6.8mH 0.35Ω 120W 65x39mm	£12.00
F1000	10mH 0.45Ω 100W 65x39mm	£13.50

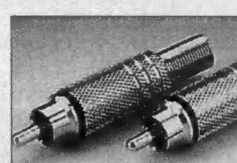
Quality Valves  
Affordable range of High Quality Valves

Part No.	Description	Price
6550C	OUTPUT VALVE	£26.00
BL6GT	OUTPUT VALVE	£4.50
6N6GT	OUTPUT VALVE	£4.50
6V6GT	OUTPUT VALVE	£3.85
EC31	TRIODE	£4.50
EC32	TRIODE	£4.50
EC33	TRIODE	£4.50
EP86	LOW NOISE PENTODE	£3.50
EL34	OUTPUT VALVE	£8.50
EL84	OUTPUT VALVE	£3.50
GE34	RECTIFIER	£6.50
KT88	OUTPUT VALVE	£20.00

Valve Holders - High quality valve bases. Chassis mounting with screw fittings.

Part No.	Description	Price
89AC	B8A VALVE HOLDER CERAMIC	£1.50
89AU	B8A VALVE HOLDER CERAMIC + 2.00 SCREENING CAN	£2.25
OC7C	OCTAL VALVE HOLDER CERAMIC £2.00	
OC7P	OCTAL VALVE HOLDER PHENOLITE £1.50	

Fully Gold Plated Phono (RCA) Plugs  
With spring coil cable grip.



Part No.	Description	Price
PPG5A2	PAIR GOLD PLUGS for up to 5mm CABLE	£1.50 pair
PPG8A2	PAIR GOLD PLUGS for up to 8mm CABLE	£1.50 pair

Very High Quality Phono (RCA) Plugs



Very high quality satin grey metal with heavy gold plated connectors. Top collet cable grip & PTFE insulators. Very low noise.

Part No.	Description	Price
PPG6H2	GOLD PTFE PLUGS for up to 6mm CABLE	£3.50 pair
PPG8H2	GOLD PTFE PLUGS for up to 8mm CABLE	£3.50 pair

Neutrik Pro-Audio Super Quality Gold Plated Phono (RCA) Plugs



Superior pair of phono each includes 2 cable grips pairs 3.5-5.5mm & 5.5-7.3mm making them suitable for a

wide range of cables. These connectors make contact with ground first at insertion to eliminate pop.

Part No.	Description	Price
PPH2	NEUTRIK PRO AUDIO	£12.00/pair

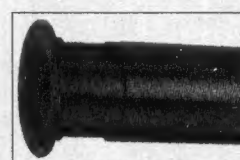
Extra High Quality Gold Plated Phono  
Oxygen Free (RCA) Leads (pairs)



Available in 2 colours & 3 lengths. Highly flexible oxygen free cable with extra moulded-in control/grounding wire.

Part No.	Length/Colour	Price
LPP1QV	0.8 Metres/Green	£5.50
LPP1QV	0.8 Metres/Violet	£5.50
LPP2QV	1.5 Metres/Green	£6.50
LPP2QV	1.5 Metres/Violet	£6.50
LPP5QV	5 Metres/Green	£11.00
LPP5QV	5 Metres/Violet	£11.00

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Part No.	Dimensions	Price
R35	d=35L=110-210	£2.50
R50	d=50L=150-280	£3.00
R70	d=70L=128-245	£3.50
R100	d=100L=160-122	£5.50
R85	d=85 angled 45° for narrow cabinets L=210-310	£6.50

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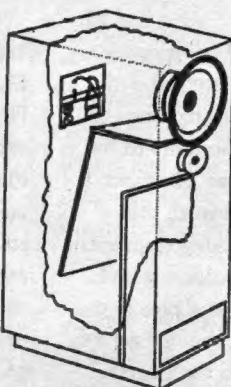
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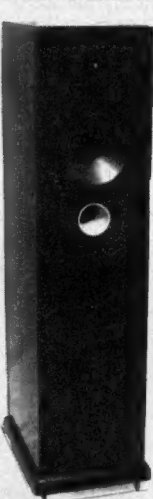
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PLUS KITS .....£172.00 -  
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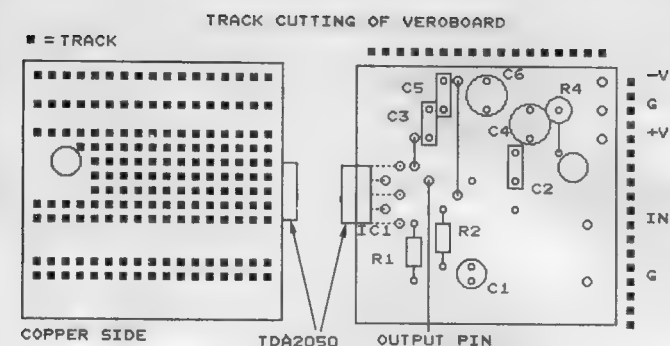


Fig 3 Amp board layout

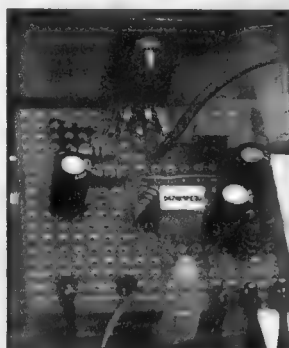
the + connection of the bridge rectifier. Do the same for the negative wire from the second capacitor, taking it to negative on the bridge rectifier. Solder the free positive and negative capacitor terminals together and take them to the star earth through another wire. See Fig 2.

The bridge rectifier converts the AC voltage from the mains transformer into a DC voltage that powers the chip. The two reservoir capacitors hold the voltage stable during high signal levels, smooth out hum and ensure that the amplifiers do not effectively run out of steam.

## BUILDING THE BOARDS

Mount the smallest components first. These are the resistors which are colour coded in accordance to the value and tolerance of the component. In the parts listing, the colour code

sequence for each resistor is described, so that you can familiarise yourself with this coding. You will notice that R4 is mounted vertically.



Once the resistors are in place, you can now see where the tracks need cutting, with a specialist Veroboard cutter or a 3.5 - 4mm drill. Do not cut into the board too hard or it will break or the hole will be too big. Cut just enough to remove the copper.

Mount and solder the terminal pins to the board

now, to save any damage later. These pins can sometimes be very stiff to put in the holes. Use either the special Veropin tool or a small pair of pliers on the edge of a hard surface, say a piece of wood.

Next mount the capacitors. All have their values and working voltages printed on the side of the part.

Make sure the electrolytic capacitors are fitted the right way round. The bar or dashed line usually corresponds to the negative terminal of the capacitor.

The low value polyester capacitors ( the ones without a polarity marking ) are non-polar and can be placed any way round without the need to observe the polarity.

Finally fit the TDA2050, making sure not to bend the pre-formed legs too far from their original position as they are quite fragile. They should easily fit into the 0.1" pitch of the Veroboard. Having built the first power amplifier board triple check everything and when you are sure that the board matches the drawing, use it as the reference for the next one.

## BUILDING THE CASE

The case is purchased undrilled. Our photograph shows how the prototype was constructed.

Drill the holes to accommodate the volume control and mains switch on the front panel. Drill the holes for the back panel second and, lastly, the holes on the underside of the case.

To form the square hole needed for the push-fit mains switch, measure the switch and mark the square hole with a felt

pen. With an electric or hand drill use a 3mm drill bit to start the hole in the centre. Enlarge it with a 10mm drill bit, then with a small round file enlarge this hole until it is as close to the switch outline as possible. Use a small flat file to put in squared corners.

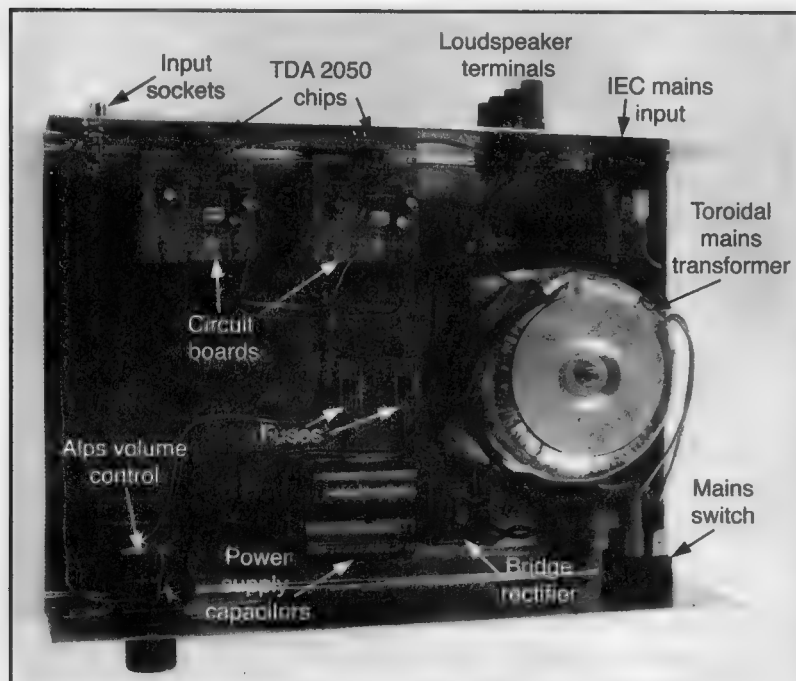
Use the same procedure for the Mains IEC socket on the rear of the case. This socket should be mounted in line with the switch on the rear of the case, so that you use the minimum amount of wire to connect these two parts together. The fixing holes for the socket are normally M3 (Metric 3mm).

Place the mains transformer inside the case on the switch side. Leaving 15-20mm gap from the side of the case mark the centre of the transformer and drill the M4 / M5 hole required for the mounting bolt. Do not fit the mains transformer yet.

Look on the mains transformer body and follow the instructions to connect it to the mains supply.

Fit sleeved spade connectors to the transformer primary leads, carefully cleaning the ends of the wires with a sharp blade just in case they are dirty. Make sure to crimp the connectors properly with a pair of pliers, so as to make the best connection and finish this area by making up the lead that links between the switch and the IEC socket. Check the connections to the switch with Fig 2, to make sure that these connections do not short the mains when the switch is activated. Fig 2 shows the normal connections for a standard double pole rocker type switch.

Finally connect the earth wire and secure one end to the case, using a solder tag and an M3 screw and nut to firmly fit it to the case. You can now fit the mains transformer to the case, using the supplied hardware. Lightly tighten the fixing bolt, but not too tight.



# HART

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We have always led the field for easy home construction to professional standards, even in the sixties we were using easily assembled printed circuits when Heathkit in America were still using tagboards! Many years of experience and innovation, going back to the early Dinsdale and Bailey classics gives us incomparable design background in the needs of the home constructor. This simply means that building a Hart kit is a real pleasure, resulting in a piece of equipment that not only saves you money but you will be proud to own.

Why not buy the reprints and construction manual for the kit you are interested in to see how easy it is to build your own equipment the HART way. The FULL cost can be credited against your subsequent kit purchase.

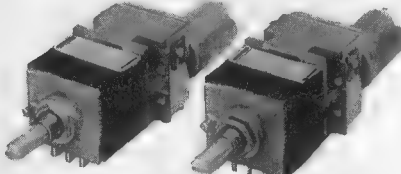
### 'AUDIO DESIGN' 80 WATT POWER AMPLIFIER.



This fantastic John Linsley Hood designed amplifier is the flagship of our range, and the ideal powerhouse for your ultimate hi fi system. This kit is your way to get EK performance at bargain basement prices. Unique design features such as fully FET stabilised power supplies give this amplifier World Class performance with startling clarity and transparency of sound, allied to the famous HART quality components and ease of construction. Standard model comes with a versatile passive front-end giving switched inputs, with ALPS precision 'Blue Velvet' low-noise volume and balance controls, no need for an external preamp. Construction is very simple and enjoyable with all the difficult work done for you, even the wiring is pre-terminated, ready for instant use! All versions are available with Standard components or specially selected Super Audiophile components and Gold Plated speaker terminals and all are also available factory assembled.

K1100S Complete STANDARD Stereo Amplifier Kit, . . . £415.21  
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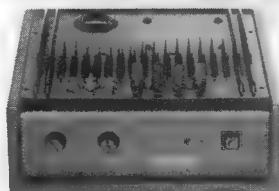
Special set of toroidal transformers, 2 output & 1 mains for the 'Hot Audio Power' valve amplifier design described in the Oct. 1995 issue of 'Wireless World'. Total Wt 4.8kg. Special price for the set. £99, Post £8. Photocopies of Article by Jeff Macaulay. £2.00

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Full Kit in 3u high Rackmount Case, . . . . . £388.25  
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This attractive module consists of a low pass filter and power amplifier ready for you to mount in a suitable sub-woofer cabinet. The combined unit can then be combined with any new or existing hi fi or home cinema speaker system to add in the real bass punch missing from most setups.

The ASM 100 module comes as a ready-to-mount unit on a solid diecast aluminium frame/heatsink. Input signal can be at line or speaker level for easy system integration. There are three separate stereo inputs at line level and the unit will use any signal presented or mix all inputs to add bass to any signal. The speaker level inputs are used by simply wiring the unit in parallel with the existing speakers to provide them with strong bass support. Crossover frequency can be selected to 50, 100 or 200Hz and the bass level can be adjusted by a front panel control. The 'Green' power supply switches the unit to standby if no signal is present. Drawings are included free for the compact 418 x 380 x 303mm cabinet. With its powerful 125 watt output and versatile filtering the ASM 100 is the ideal universal active driver module for all subwoofer requirements.

ASM 100 Module, complete with IEC mains lead, instructions and ASM - W20 cabinet drawings. Pt. No. V7000. . . . . £185.29  
W 200 S 20cm Long Throw Drive unit for use in ASM - W20 cabinet. . . . . £36.68

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To complement the sound purity of such amplifiers a full three speaker system is used with a 300mm (12") woofer, 200mm (8") mid-range and high quality horn tweeter in a vented bass reflex enclosure.

All these drive units have been carefully selected for their individual virtues, and collective excellence, the tweeter for instance being a high end unit with exceptional pulse response as a result of its combination of Kapton former, aluminium diaphragm and aluminium voice coil.

Nominal Power Rating is 150W, Max. Music Power 250W, Impedance 8 ohm, Mean Sound Pressure 91dB. Speaker kit comes with all parts to make a pair of speakers, but not the cabinet parts. Crossover units are factory assembled, ready to fit.

Kit No.LK5963 Per Pair. . . . . £424.93

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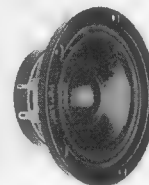
The VISATON range of speaker kits includes all you will ever need for your surround sound home cinema setup. The Hi-Tower Kit is ideal as a super luxury pair of stereo main speakers. The 'Centre 80' uses special magnetically screened drivers to avoid picture disturbance and a pair of 'Effect 80's are used as rear speakers. Any of a range of sub-woofers then adds weight to the sound of the robot feet. Centre 80 Kits include drive units, crossover, terminals and grille. (You make the box) Price each. . . . . £64.08  
Effect 80, Rear Speaker Kits, per pair, . . . . . £39.00

### DRIVE UNITS.



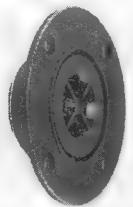
**BG30NG 30cm. (12") Woofer.** High efficiency, (95db) for sealed or vented cabinets. Peak power handling 250watts. 8 ohm. £89.61

**W200S 20cm. (8") Woofer.** Long throw unit with rubber surround and extended rear pole to give no less than 20mm cone displacement. Ideal for compact sub-woofers such as ASM-W20. 8ohm. £36.68  
NG8 Protective Metal Grille. £5.66



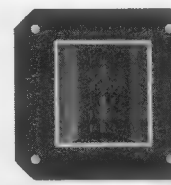
**W100S 10cm (4") Low/Midrange.** Coated paper cone, rubber surround, high temperature voice coil. Suitable as woofer in mini enclosures or midrange in 3-way systems. 4ohm. £18.06  
NG4 Protective Metal Grille. £3.20

**FRS8 8cm.(3.3") Fullrange driver.** Linear frequency response between 200 and 20KHz. Large Magnet, 20mm voice coil and rubber surround. 8ohm. £8.36



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**SC5 10mm. Magnetically shielded Tweeter** for use in surround sound centre speakers. 8ohm. £9.24



**RHT12S High End Ribbon Tweeter.** Superior double magnet construction gives an exceptionally low distortion and linear response from 4,000 to 30,000Hz. Cabinet cutout diameter 95mm. 8ohm. £87.77

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Connect the linking wires from the power supply to each of the two power amp boards. Now fit the volume control and solder the two dual-screened wires to this

case, making sure that the isolating bushes supplied fully isolate the sockets from the case and the sockets are secured tightly.

Wire up the speaker

power supply board earth (Fig 2). The positive lead connects to the amplifier board output pin.

Now is the time to mount each of the two amplifier boards in turn. An isolating mica washer goes between the 2050 tab and the metal of the case; it conducts heat but not electricity. Apply heat sink compound to the device and to the mica. Fit the stand-off spacer to the case and carefully mate the board to the back panel. Push an M3 screw through from the outside. Fit the screw isolating bush (used with metal screws) and lightly tighten the securing nut. Once the board is secured on the back, gently push the board onto the

stand-off. Finally, solder on all linking wires.

If you plan to use the optional heatsink, put some heat sink compound on the back and mount this to the rear of the case.

Once everything is fitted into the case, check all of the connections. Power up the unit and follow the instructions described earlier. Make final checks, connect everything up, put the 3.15A fuses into the internal fuse holders, switch on and try some music ●

## HEATSINKING

Use as much heatsinking as possible to keep the chips cool. SGS Thomson recommend 60mm of a 4.2C/W rated profile, per chip. If the amplifier is not to be driven hard, then a thick plate of aluminium (12gauge) will conduct heat away adequately. If it isn't big enough the chip will simply shut down temporarily.

Maplin stock a range of heatsinks for TO220 packages that will allow higher dissipation, like their KL-100-1, price £3.99.

and to the audio input sockets. The floating wires from the volume control connect to the amplifier boards.

Fit the speaker connectors to the rear of the

terminals with two short runs of either 49 or 72 strand speaker cable. The rib on the cable normally connects to the negative terminal, the other end of the ribbed wire going to the

## PARTS LISTING

### AMPLIFIER BOARD PARTS

Resistors	3 Band Colours	4 Band Colours	
R1 100K $\Omega$ 1/4W Metal film	Black Brown Yellow	Black Brown Orange Brown	Qty 2
R2 680 $\Omega$ 1/4W Metal film	Blue Grey Brown	Blue Grey Black Black	Qty 2
R3 22K $\Omega$ 1/4W Metal film	Red Red Orange	Red Red Red Brown	Qty 2
R4 2 $\Omega$ 1/4W Metal film	Red Red Gold		Qty 2
VR1 50K $\Omega$ Stereo Log Potentiometer			Qty 1
IC1 TDA2050			Qty 2

### CAPACITORS

C1 100 $\mu$ F Electrolytic 25V	marked on body of component	Qty 2
C2 0.47 $\mu$ F Polyester 63V	marked on body of component	Qty 2
C3 0.1 $\mu$ F Polyester 63V	marked on body of component	Qty 2
C4 100 $\mu$ F Electrolytic 25V	marked on body of component	Qty 2
C5 0.1 $\mu$ F Polyester 63V	marked on body of component	Qty 2
C6 100 $\mu$ F Electrolytic 25V	marked on body of component	Qty 2

### POWER SUPPLY PARTS

Bridge Rectifier	KBP02506	marked on body of component	Qty 1
C7 4700 $\mu$ F	Electrolytic 50V	marked on body of component	Qty 1
C8 4700 $\mu$ F	Electrolytic 50V	marked on body of component	Qty 1

### MISC. COMPONENTS

Mains Transformer	Maplins DH63T		Qty 1
Case			Qty 1
Mains IEC socket with internal fuse holder			Qty 1
500mA 20mm Anti-surge fuse			Qty 1
3.15A 20mm Anti-surge fuses			Qty 2
Chassis mounted fuse holders			Qty 2
DPDT Rocker mains switch			Qty 1
Red 4mm Banana sockets			Qty 2
Black 4mm Banana sockets			Qty 2
Sleeved spade connectors			Qty 7
Assorted colours of wire, including 12" of 3A mains cable			
Veroboard			Qty 1
Veropins			Qty 1 pack
Plastic stand-off spacers			Qty 2
Assorted length M3 screws, nuts and washers			

Most of the components were sourced from Cricklewood Electronics London, with the exception of the potentiometer which is from an ALPS dealer and the transformer from Maplins.

## MEASURED PERFORMANCE

Frequency response was very wide at 5Hz-150kHz. The upper limit is arguably too high; we noticed slew rate limiting occurring. However, CD cannot deliver signals above 21kHz, so this should not be a problem in practice. There is plenty of leeway here for feedback reduction.

Power output depends upon supply volts. What you have to bear in mind is that the tiny Pentawatt package must have heat drained from it fast if it is to deliver full power without running into thermal shut down. This means mounting the 2050 tabs direct onto very thick aluminium (e.g. heat sink) or copper (acting as a heat conductor to a sink).

Distortion was low even at high frequencies, an impressive result. This really is a well worked out amplifier design. Distortion figures were low enough for some feedback reduction to be tolerable.

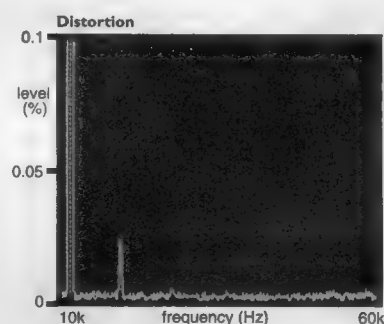
At 500mV for full output, sensitivity was high enough to suit most, if not all sources. Some budget cassette decks and tuners deliver just 300mV. Otherwise, most sources nowadays deliver 500mV-1V, CD delivering 2V of course. So this amp, as it stands, will match most sources. Sensitivity can be increased by reducing feedback.

There were no switch-on thumps and D.C. output offset measured a very low 1.7mV / 2.4mV, much like that of quality commercial amplifiers.

The TDA2050 offers a level of measured performance similar or better than everyday commercial designs. It's great for DIYers. NK

Power (8 $\Omega$ )	32watts
Frequency response	5Hz-150kHz
Separation	85dB
Noise (CCIR)	-101dB
Sensitivity	500mV
dc offset	1.7 / 2.4mV

Distortion (8 $\Omega$ )	1W	full o/p
1k	0.02%	0.04%
10k	0.01%	0.13%









# TWEAKED! - WITH SPECIAL COMPONENTS



**Around the world, high quality electronic components for audio work are being produced by specialist manufacturers. Noel Keywood and Jon Marks review some esoteric capacitors and resistors from this field.**

Component quality is ever more widely being identified as an issue affecting sound quality. But prices remain a barrier to widespread commercial usage of the most esoteric items. But not to DIYers, who can upgrade 'at cost'.

Proper audio grade components are truly esoteric items, often with peculiar descriptions, complex performance claims and high prices. They're great for DIYers, providing an opportunity to step up in quality to a level beyond the reach of the mass audio market.

Component quality has always been an issue at Hi-Fi World. We have our own transformers and capacitors made for us and through practical experience have become well aware of the sonic signature of many components, both general purpose and audio grade. And the character of a component invariably comes

through irrespective of working conditions.

But this business is complex. Many budget components sound quite good - carbon film resistors for example. High grade components not meant specifically for audio work do not always sound better - some polypropylene capacitors for instance.

And it can be disastrous to populate an amplifier with a component having a particularly strong signature. One time, every resistor in a K5881 amplifier was misguidedly changed to metal film - it sounded awful, hard and clattery. So this is a mix 'n' match business too.

It is also a decidedly subjective business where notions of absolute correctness are hard to support. Quite often, however, there is a broad consensus, but that's very different to total agreement. A 'hard sound' can suit vinyl, but not CD.

My experience is that differences in component sound quality are easier to discern on a valve amplifier than a solid-state amplifier. This view arises from changing components in a 300B alongside our 36watt Class A design. So we used a K5881 MkII for this report, changing the components shown in the circuit diagram.

Modern plastic capacitors use a film metallised on both sides. It can be polyester, polycarbonate or polypropylene. The film is usually aluminium, its thickness determining the voltage rating. The Wondercaps tested in this report use metallised film construction.

Audio grade capacitors sometimes use a foil and film construction, which is much bulkier.

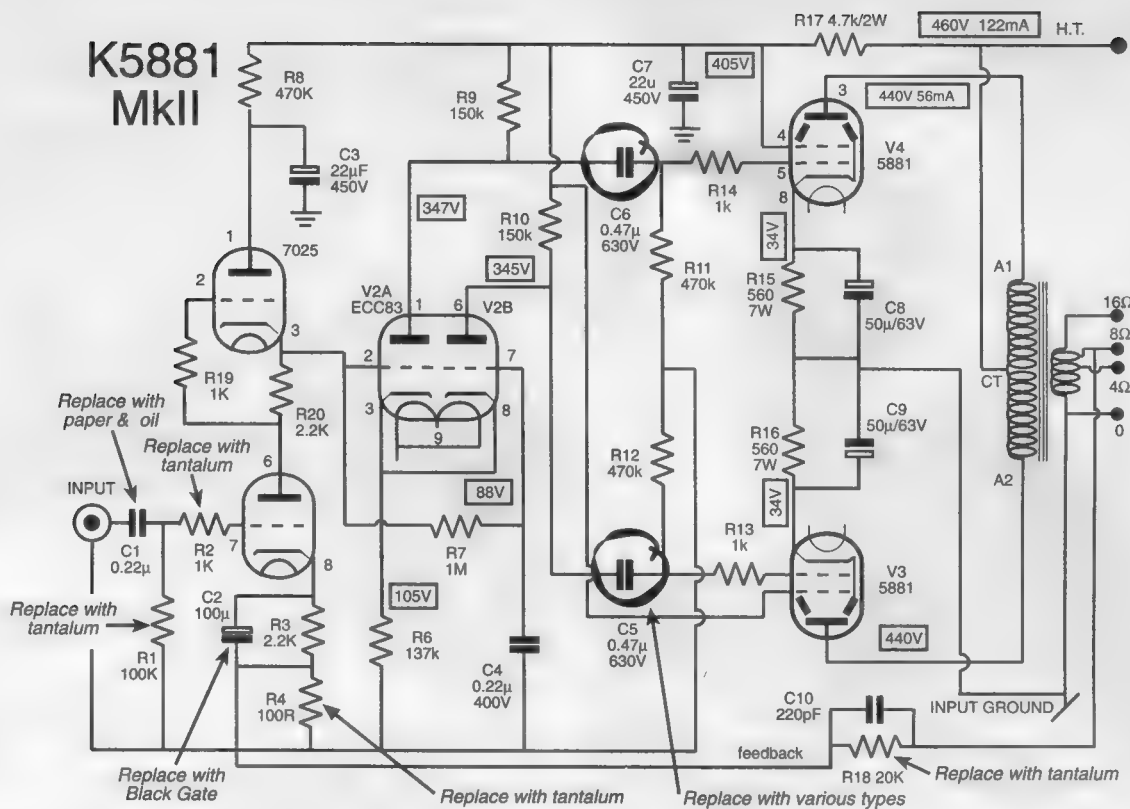
Then there's paper-in-oil. This is a rare dielectric type nowadays - we've found one manufacturer in Britain who produces it for military

purposes. These capacitors are made by forcing oil into paper under pressure and heating in a sealed tank. It's an old-fashioned method that yields variable results. Paper-in-oils can leak (electricity - not oil!) but they have a good reputation for sound quality.

Electrolytics provide very high capacitance from small size, but have mediocre performance in most other areas. There are legions of special types as a result. Rubycon make various audio grade specials, like the famous Black Gate. This reputedly uses an electrolyte with a graphite additive, developed by Japanese manufacturer Jelmax.

Carbon film resistors are most common and usually sound pretty good. Metal film types such as Holcos are considered a step up, but for this report we tested tantalum film resistors, manufactured in Japan and imported into Britain by AudioNote.





#### THE COMPONENTS WE TWEAKED

**COUPLING CAPACITORS C5 & C6** - In this position the K5881 kit's standard capacitor is a 0.47µF metallised film polyester capacitor with 400V across it. In its place we soldered in: HOVLAND MUSICAP 0.47µF 600V film and polypropylene foil capacitors; TRT WONDERCAP 1µF 425V metallised polypropylene film capacitors; AUDIO NOTE paper-in-oil 0.39µF 600V capacitors.

**INPUT CAPACITOR C1** - This was replaced with an AudioNote 0.22µF 400V paper-in-oil.

**FEEDBACK BYPASS CAPACITOR C2** - This was replaced with a 100µF 6.3V Rubycon Black Gate electrolytic.

**INPUT AND FEEDBACK RESISTORS** - These were replaced with tantalum resistors.

#### STANDARD POLYESTER CAPACITORS (56p each)

JM - Tori Amos' vocals and harpsichord were both powerful and smooth, integrated within an acoustic whose size was clearly audible through the Sextet IIs. The grungey electric guitars which join the song in its second half had an attractive 60-a-day roughness to them, which is just as it should be. Individual images hung together in a cohesive sound stage, good tonal balance leading to an even-handed presentation.

The ebb and flow of piano and strings showed that dynamic contrasts posed these caps no problems, with further proof in the weight of the piano's bottom end and the expressiveness of vocals. Extra bass brownie points were garnered for the focus and impact of the conga on 'Talula' and the drum

machine on 'Professional Widow'.

The acoustic was once again well fleshed out on Vivaldi's Four Seasons, where imaging was stable, separation good and detail fine. Rhythm and timing were also present and correct, as I found out with the 'Danza Pastorale', its violins tripping along, joined by the drive of the well defined cellos.

NK - Very clear and precise. Typical film capacitor glassiness, close to audio grades but a little less insight, fine detail and smoothness.



#### AUDIONOTE PAPER-IN-OIL CAPS (£12.75 each)



Bass immediately stood out for its extra detail, speed, impact, extension and focus. It was as if someone had hit the loudness switch, but instead of fat, bloated lower registers, there was suddenly another octave of hard-hitting bass on tap. As a self-

confessed bass-head, the AudioNotes produced the kind of taut, tuneful bass that put a grin straight on my face - the groove factor in the music had just risen a couple of notches on the shake-your-booty meter.

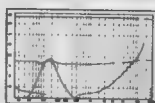
The sound as a whole opened out, different layers within the sound stage becoming more obvious - individual images were now easier to make out within the larger acoustic these capacitors developed. They also showed an overall control and grip which never quashed the vitality of the music, instead enhancing it by making the music easier to listen in to.

There was greater detailing to images as well, giving them a fuller, more three-dimensional feel and knitting them more convincingly into the sound stage. This detailing extended to the treble, with cymbals and strings benefiting from

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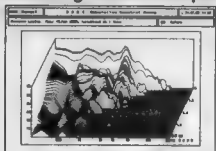
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impressive tonal subtlety and insight.

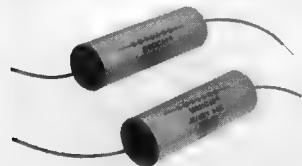
One major difference between the AudioNotes and the standard capacitors was a softer midrange that was less forward and incisive, giving Rock a mellower character. NK - Always different from synthetic film capacitors, these paper-in-oils soften out the mid-band a little but give enormous amounts of clean high frequency detail. Most surprising was their significant extra bass extension, with improved impact and raised level.

### HOVLAND MUSICAPS (£12.86 each)

The Hovlands' midrange is similar in presentation to the standards' in its forwardness, but has a delicacy of detail closer to the paper-in-oil capacitors. Tonally, the Musicaps had a wider palette to paint from as well, with violins and cymbals in particular coming across more realistically.

While the Hovlands' bass was tight, detailed and fast, it lacked the sheer weight and impact that the AudioNotes possessed. This meant that acoustics were rendered on a smaller scale, the sound stage missing out on some of the width and depth that had been discernible with the paper-in-oils.

The overall balance of the music tipped away from the visceral of the AudioNotes towards the analytical, becoming a little less engaging in the process. Rock fans



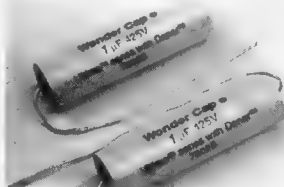
might well go for this approach with its crisp, precise speed though. And the way images stood out cleanly in the acoustic means that these caps will never sound confused, even on the heaviest of mixes. NK - Similar in basic

presentation to the standard polyesters, but with stronger outlining, more detail and more upper midband projection.

### TRT WONDERCAPS (£5.50 each)

These capacitors continued the plastic family tradition of forward and incisive midrange, as the likes of Grace Jones, the Chemical Brothers and Vivaldi proved. With the latter there was a broader sound stage and deeper bass than had been the case with the Musicaps. The music flowed along rhythmically, these caps showing off their prowess in the timing area with an impressively foot-tapping rendition of 'Setting Sun'. Detail was abundant - I had no problem homing in on the individual samples plastered all over this song. While the TRTs' bass plumbed greater depths than the Hovlands, it didn't go as low as the AudioNotes.

Vocals proved the



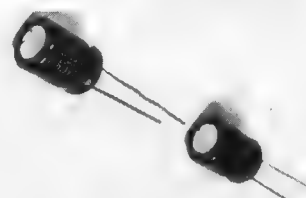
smoothness and power of these caps, with the expression in Tori Amos' singing particularly impressive. Backing violins and harpsichord were less glassy due to a broad tonal range that fell halfway between the paper-in-oils and the Musicaps. Images were properly detailed and proportioned and sat within an attractively transparent sound stage. The TRTs seemed to combine the incisive, forward midrange characteristic of the plastic caps in this test with some of the broad tonal range and low-level detail retrieval of the paper-in-oils. NK - A little less extreme in upper mid-band glassiness and projection than the

Hovlands, a little better in overall balance due to stronger bass too, although not a match for the paper-in-oils. Very good.

### JELMAX BLACK GATES (£1.83 each)

The effect these tiny electrolytic capacitors had on the sound quality was far from small. From the first moment that music started coming through the Sextet IIs, it was obvious the Black Gates had cleaned up the overall sound, removing a layer of grunge from the amplifier's presentation.

Tori Amos' piano and vocals were now firmer as well as more dynamic and realistic, their images packed full of a subtle detailing that never became overwhelming.



The band members were solidly positioned in an acoustic made recognisable thanks to the transparency the Black Gates brought to the proceedings. With the extra breadth and width the sound stage now possessed, music took on life-like proportions and was much more involving.

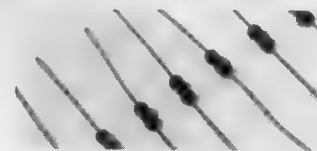
The Black Gates seemed to have a similar affect to the paper-in-oils where bass was concerned. They removed the mush that normally obscures the cues in the lower octaves that build up an acoustic and add space to the sound stage. But they also tidied up the performance of midrange and treble, with greater insight and detail, especially obvious on strings, lending Vivaldi's Four Seasons a realism that made listening addictive.

NK - Phew! The Black Gate lived up to its reputation, one little capacitor immediately improving image body and solidity right across the audio band. This component change

was the best we made in my view.

### AUDIONOTE TANTALUM RESISTORS (£1.99 each)

NK - These were added into the circuit in the positions shown in the circuit diagram. Their effect was quite obvious, being not too dissimilar to that of metal film resistors. They brightened and hardened up the sound, adding some high frequency



'hiss' to cymbals that warned there was now a little too much emphasis on high frequency retrieval. Our overall view here was that these resistors need to be used with care and according to conditions. The Tonigen ribbon tweeter of the Heybrook Sextets is one of the most revealing going; others may make more or less of the effect. Also, what comes over as extreme glassiness and hardness with CD sounds far more acceptable with LP, posing the question: are these components simply revealing more of CD's problems?

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Technical specification: dual mono construction, 40W/channel, 12Hz to 25kHz power bandwidth, distortion <0.1%, five line level inputs, tape output, 230/240V mains input.

Stereo amplifier circuit board: board only £49.50; component pack (including valve bases), add £63; populated board £125; full valve set, add £45. Power supply board: board only £20.50; component pack, add £44; populated board £66. Input board: board only £15.50; component pack, add £16; populated board £33.

The output transformers are configured for the McIntosh connection and have excellent low frequency response and a primary reflected impedance of 3800Ω. Full connection instructions provided. Price £70. The mains transformer is wound for dual mono construction, as this gives superior isolation between channels which sharpens imaging and eliminates inter-channel ground loops in the amplifier. Primary 0-230-240V. Secondaries 2x295V@0.25A (0.4A int.), 2x70V@30mA, 2x6.3V@5A. Price £60. Other primary voltages can be supplied to special order. Data sheets giving connection diagrams, specifications, as well as circuits for using each transformer, £2.50 each.

The chassis, comprising main chassis and transformer cover, is hand polished, welded 1/16" stainless steel - NC machine tooled for a perfect fit and clean finish. Each kit also includes a mesh valve cover and baseplate, finished in

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Technical specification: 47kΩ input impedance, 1kΩ impedance output for driving long interconnects.

Stereo circuit board: board only £25; component pack, add £37.50; populated board £70; full valve set £20.

The mains transformer is wound for dual mono construction and is toroidal for low leakage flux. Primary 0-230-240V. Secondaries 2x295V@20mA, 2x6.3V@0.45A, 16V@1A. Price £30. Other primary voltages can be supplied to special order. These transformers are also suitable for power supplies in preamplifiers and other line level valve circuits - see data sheet for details, £2.50.

The chassis (main chassis and transformer cover) is made from mild steel. Each kit comes complete with a mesh valve cover and baseplate, finished in black. Price £110. For those who wish to use a high quality chassis for their own projects, details of the chassis are given in the P2 manual, £6.50.

Connector kit: four gold plated phono connectors, IEC mains socket with integral fuse and switch, and IEC mains lead with fitted 13A plug, £15.

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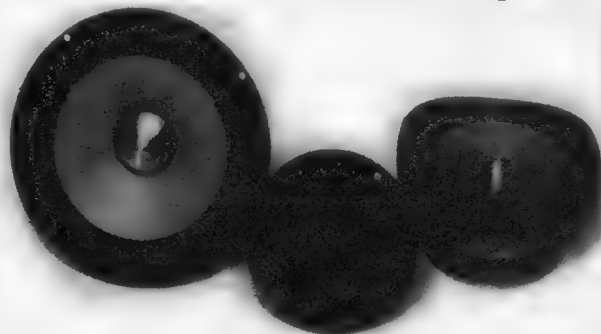
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# ACOUSTICS and PSYCHOACOUSTICS

by David Howard and James Angus.

Reviewed by Noel Keywood.

**B**ooks on acoustics are becoming more common, but each has its own particular approach to the subject. Traditionally, the area has been split between two camps: musicians and architects. Seashore's *Psychology of Music* (McGraw Hill) is an early example of the first and Beranek's *Acoustics*, available from our World Library (p58), an example of the second.

Both are what I would loosely term 'mechanistic'. There is another emergent camp that approaches the subject from the other direction, looking at audible perceptive strategies from the biological viewpoint. It seeks to understand our hearing function in evolutionary (Webster, Popper and Fay) and psychological developmental terms. This approach concentrates on our interpretations of what we hear, is a branch of medical science and is producing, in parallel to the mechanists, a large body of fascinating information. As Yost says, "in the past a distinction has been made between sensation and perception", perception being treated in vague terms.

The traditional mechanistic approach to psychoacoustics is under fire from others in the field, who feel its explanations either don't go far enough or are just plain useless. "A number of investigators have argued that audiogram thresholds and other psychoacoustic measures correlate poorly or not at all with those measures attempting to tap a listener's ability to function acoustically in daily life".

I mention all this to get *Acoustics and Psychoacoustics* into perspective. It comes firmly from the mechanist camp. And it does a good job. But when I see the word "psychoacoustics" I do rather wonder whether I've got to plough through dense paragraphs and complex diagrams of hairy cochleas, of more use to a surgeon than someone, like myself or a potential purchaser of this book, who needs to make sense of our senses.

In this case, the cochleas have it, together with the conchas, incus and all manner of auditory bits and pieces, from

page 66 onward. However, that is not to deny that the book covers valuable ground. It is written by and aimed at those interested in music recording and performance.

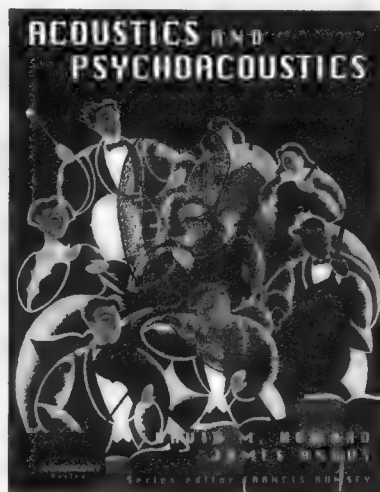
Early chapters cover the usual ground, considering air speed, wave compression, reflection, refraction, resonance and various other physical phenomena. There is a useful number of equations, but the authors have tried to make the book easy to comprehend. The explanations are nonetheless comprehensive and detailed.

After talking about the physics of sound and the biology of the human auditory system, the book moves in apparently logical progression to *Notes and Harmony*. Here we are getting firmly into music theory and some of it I found fascinating. I had always thought that the good Dr Ohm was an expert on

Masking follow, with the inevitable reference to 'deception' that engineers make when discussing masking effects. I'm sure Yost would see 'deception' more as a sophisticated biological form of 'optimisation'.

The penultimate chapter considers rooms, studios and acoustics. It covers basic theory more than practical acoustics solutions, although I was amused to see the use of side wall absorbers to produce a reflection-free listening zone in a room, since we regularly recommend this. However, the influence of the rear wall, and of diffraction as an alternative to adsorption, are not discussed. The book quite often resorts to theoretical generalising where, I suspect, the authors have little practical knowledge. And finally, in the last chapter, electronic sound processing, including equalisation, phasing, reverberation, compression and other studio effects are covered very quickly.

Leaving me to categorise this book as a good choice for music students - and ear surgeons. Its approach is more theoretical than practical, but for anyone studying acoustics for the first time the explanations are about as easy as they come and the coverage wide too. But everyone in audio ought to be aware that human auditory perceptive strategies are not as simple and mechanistic as traditionally presented in books like this. Making the scope of the 'psychoacoustic' contribution a bit limited and limiting. I would like to have seen a bit more breadth of discussion in this important and profound area ●



current through resistors, but it seems he also developed an acoustical law. Coverage of psychoacoustics from this point of view, namely how we perceive groups of tones and such like, is thorough and well supported with references, both within the chapter and at its end.

The arrival of Chapter 4 clearly signals which way this book is heading. Entitled *Acoustic Model for Musical Instruments* it explains how musical instruments work, including human vocalists. The subjects of Timbre and

**Acoustics and Psychoacoustics**

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# AUDIO POWER AMPLIFIER DESIGN HANDBOOK

*by Douglas Self.*

**Reviewed by Andy Grove.**

**T**he Audio Power Amplifier Handbook follows from a series of articles by Douglas Self published in *Electronics and Wireless World*, but of course the book allows the author to cover the subjects in greater depth. Mr Self is a respected audio engineer and currently designs professional equipment such as consoles for the Soundcraft Electronics company.

Douglas has analysed the distortion mechanisms of the various stages of the amplifier and presents methods for their reduction or elimination. In the opening chapter Doug attacks the subjectivist movement with a vengeance. It's all done very logically and the arguments presented seem valid. Here also the general requirements of power amp performance are laid out, with safety and reliability first and foremost, progressing through well known lab test parameters such as damping factor and distortion.

The second chapter gives the reader a quick overview of two possible amplifier topologies. The different classes of operation such as A, B, and H are described quite briefly, but the book really concentrates on Class B output stages. A 'for' and 'against' list of features for AC and DC coupled amplifiers is also presented. From there Self goes on to justify the use of negative feedback, his argument mainly hinging on how it reduces distortion. But he also points out that the distortions produced at each stage can be minimised before feedback is applied, maximising its effect.

In Chapter 3, Self's eight distortion mechanisms are introduced. These are distortions which he seeks to reduce to make an amplifier more linear, before feedback is applied. Here also the 'generic amplifier' is introduced. This is the almost universally used three-stage circuit with input differential pair, voltage amplifier and output buffers.

The next three chapters offer a step-by-step analysis of the generic circuit, starting at the input differential pair and proceeding through the voltage amplifier to the output stage. The analyses are in depth and Spice models are used to predict behaviour, together with some

real-world prototype circuit tests. All kinds of goodies are described, such as current mirror loading of the input pair, constant current sourced VAS stages and the innumerable different output stage types from the simple emitter follower to complex triplets.

Chapter 7 covers the issues of

## Audio Power Amplifier Design Handbook

DOUGLAS SELF



stability, compensation and slew rate in great detail and Self illustrates the various effects of the amp's set-up, such as input stage operating current on its high frequency and slewing performance.

The following chapter investigates the power supply and its effect on performance. Even the wiring and earthing of the circuit is taken into account. This is valuable for less experienced engineers. Self concludes that the best approach is to maximise the amp's power supply rejection ratio rather than making the supply super stiff and quiet.

Chapter 9 is all about Class A amplifiers. They are introduced as a way to decrease distortion from the output and driver/voltage amplifier stages. In this chapter there is a very novel output stage quiescent current monitor and controller and the 'Trimodal' amplifier which can be a Class A, B or AB.

In Chapter 10 the FET output stage is explored, but Douglas is not a fan of the

FET, mainly due to its lower transconductance manifesting as higher distortion when used as a follower, so this chapter is quite brief.

Chapter 11, entitled 'Thermal Dynamics of Class B Output Stages' addresses just that, and Self uses Spice modelling techniques to predict thermal performance by converting various thermal elements to electrical ones. The thermal issue is a very important one, not only for the purpose of reducing distortion but for the practical reason of avoiding thermal runaway and output stage self-destruction if you get it wrong!

The final three chapters are practical and down to earth. Covering protection circuitry, mechanical design including PCB layout and final testing.

For those who want to build a reference quality solid-state amplifier this original book is essential. But it should form part of a library and not be taken as the bible of power amps because it is very specific in its coverage. There are numerous other topologies, apart from the 'generic amplifier' topology, which may or may not offer advantages.

Douglas Self has made it a personal quest to perfect this particular amp topology, something I thought Hitachi did back in the Seventies with their super high feedback MOSFET amps. Self's criterion of amp goodness is to have the maximum amount of zeroes before the one in the distortion figures. It's like trying to characterise a car from the engine's power output or wheel diameter; it's all just specs in the end.

This is an original and informative book written in a very easy to understand style, which indicates that the author knows what he is talking about. But I wish Douglas would discard his Paisley shirt and psychedelic kipper tie, put a little more faith in his senses, and a little less in his test gear.

### Audio Power Amplifier Design Handbook

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# D.I.Y. Letters

**Andy Grove (ex-Hi-Fi World, now Audio Note) says -**

You could do quite a lot to increase the sonic performance of your head amp. You could upgrade the electrolytic capacitor to Black Gate types and possibly fit tantalum film resistors, but you seem to be concentrating on the power supply and it's quite often a good place to start.

Ideally you would use a choke input filter and low noise shunt regulator. We've got some high current chokes for filament supplies at Audio Note. Using a large capacity mains transformer and reservoir caps could work quite well. Linear Technology make high performance regulator ICs. Check the audio parts guys' catalogues.

One tip is not to put a super large capacitor on the output of the regulator chip; the data sheet will advise. Also, it may be worthwhile putting a small resistor

between the output of the chip and the cap, 10 ohms say.

Another way of making a super cool regulator might be to use a high performance power op-amp IC and a voltage reference IC for each rail. Make sure the power op-amp has a good frequency response, and again be wary of using large capacitors on the reg's output.

A word of warning, shorting the regulators output may result in instantaneous destruction of the op-amp unless it is internally protected. Of course this is only likely to happen if you are careless with the meter probes. There are various circuits around in the reference books from Maplin and so on, for discrete and IC regulator circuits, check them out. AG

**Noel says**

There are many forms of power supply, each with its own strengths and weaknesses, as well as

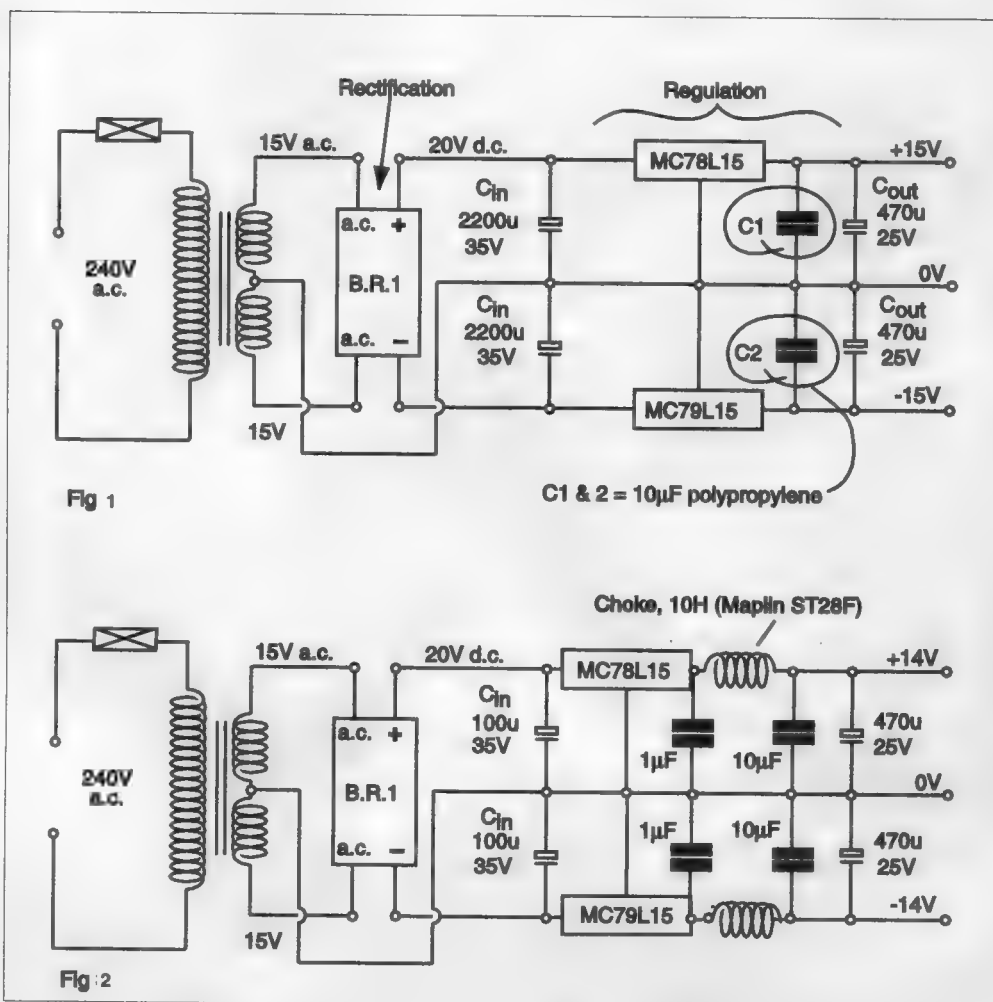
## POWERING UP

I am looking to squeeze a bit more performance out of your phono head amp, and am considering building a beefier power supply. My inspiration is the Michell ISO, which sounds much better with its Hera power supply.

Would this be a worthwhile proposition? If so, how far should I go? If I follow the Russ Andrews school I would end up with a 200VA or so transformer and 20,000µf reservoir caps on each rail. While I would be prepared to build something along these lines, I assume that something smaller would fit the bill. Can you suggest something?

Also, if I do uprate the power supply should I also replace the voltage regulators with something rated a bit higher, say 1 amp or so?

**Steve Hall**  
East Carleton,  
Norfolk.



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adherents of course. Here are some options, that relate to power supplies in general, you might like to consider.

Note what Andy says here. Furthermore, looking backward from amplifier into power supply, the amplifier

determined by its dynamic behaviour, noise etc will influence the load. So, in effect, you end up listening, in part, to the voltage regulator. That is why Andy recommends using a high performance audio power amp as a regulator; it is also why valve regulators are best.

Generally speaking, solid-state voltage regulators work best at low frequencies and invariably give tight sounding bass, but they are less pleasant across midband and treble. If you increase input capacitor  $C_{in}$  you pulse the transformer and mains supply more heavily, as transformer volts rise above  $E_{dc}$  to  $E_{peak}$  (top trace in Fig 3) which is not a good idea in principle, although in this case little current is being drawn, unlike a power amplifier.

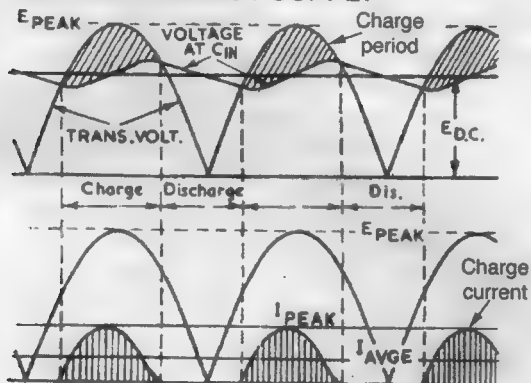
Increasing the output capacitor,  $C_{out}$ , will have little effect, because of the voltage regulator's low output impedance. All the same, you will find a large value polypropylene across the output 470 $\mu$ F electrolytic,

as shown in Fig 1, cleans the treble.

The best way to decouple the power supply from the amplifier, and to draw current more smoothly from the transformer, is to use a choke. It might seem daft to put a choke after a voltage regulator, since the DC resistance (150 $\Omega$  in the Maplin choke) destroys the regulation, but in this case the regulators are there only to guarantee the lines can't rise above 15V. A large value choke (3-10H) decouples the amplifier stage from the supply effectively and makes the output capacitor more influential. Use a 470 $\mu$ F/25V Cerafine or Black Gate as an output capacitor, optionally bypassed by an audio grade polypropylene - experiment to see what you prefer.

Providing the input capacitor is kept low, around 100 $\mu$ F or lower if hum is not a problem, then current draw from the transformer is smooth over the whole of a voltage cycle, as shown by  $I_{avg}$  in the bottom diagram.

### CAPACITOR INPUT SUPPLY



### CHOKE INPUT SUPPLY

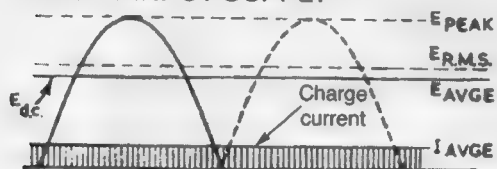


FIG 3

Our phono stage power supply uses a normal capacitor input topology where rectifier BR1 charges 2200 $\mu$ F 'input' capacitors. This provides a fairly hum free 20V that feeds the MC78L15 (+ rail) and MC79L15 (- rail) voltage regulators. These hold the output voltage steady irrespective of input voltage (i.e. mains) fluctuations or output current variations. It's simple and it guarantees DIYers a 15V line free of hum, since both the capacitors and the voltage regulator act to smooth the supply. The AD797 supply voltage is rated at 15V maximum and running the chip at full line volts gives maximum signal output swing of around 10V rms.

This is a safe, cheap and reliable supply, of a sort much used generally. However, chip voltage regulators have a very low output impedance that defies the efforts of output capacitors to swamp their influence. I've experimented with many such regulators and find they are noisy, about which little can be done.

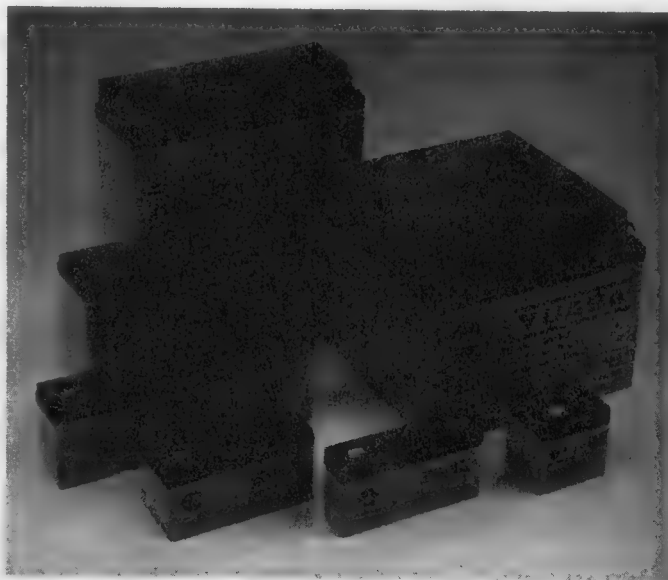
sees a solid-state power output stage. Since the amplifier effectively routes the power supply current through the load, the sound of the power supply, as

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#### Charging

Because these lead-acid batteries are sealed, some care has to be exercised whilst charging, and it is recommended that a stabilised, constant voltage source should be used, with current limiting proportional to the battery's Ah rating. Car battery type chargers must never be used. Battery performance and service life will be directly affected by the choice and efficiency of the charging circuit used. Constant voltage charging is the most suitable method, and the output must be within 2.25 to 2.30 volts per cell for trickle charging, or in the case of 'cyclic' use 2.40 to 2.50 volts per cell.



In effect, the choke, being a reactance, stores energy, releasing it into Cout and the load, during the discharge period. This will improve sound quality. You might be interested to note that Cin should be made as small as possible in this arrangement, and Cout made large. This arrangement approximates to a choke input power supply, considered something ideal, although a pig to implement I have found.

Another option seriously worth considering with a high gain, sensitive preamp in particular, is to go battery. Use two 12V sealed lead acid types, which have a very low output impedance, one for each rail. Recharge them over night. The Yuasa XG74R from Maplin at £18 apiece will suit. **NK**

## QUICKSILVER MESSENGER

In Australia I have just obtained a copy of your October '95 issue and I think I can help Andrew Footman from Wolverhampton, who asks for information on the Quicksilver amplifiers, in particular the 8417 valves.

Note that the ratings for the KT88s are for genuine GEC M.O.Valve Co. By all accounts, the Chinese derived KT88s (currently available through PM Components, Golden

Dragon, Billington Gold et al.) are better run at considerably lower plate voltage to avoid flash-over problems.

Typical operation points for all the valve types listed at a B+ of 450V are almost identical - around 50mA standing current per tube, with a grid 1 bias of -15V to -20V. In fact, the 8417 needs a slightly lower bias voltage, which means it is very easy to drive.

Based on these ratings, Andrew could directly (well, almost directly - see

RATINGS	8417	6550	KT88	EL34
Anode volts	500V	660V	800V	800V
Screen volts	500V	500V	600V	425V
Anode power	35W	42W	42W	26W
Screen power	5W	6W	6W	8W

info on pins below) substitute a KT88 or 6550 and be well within the design centres for any 8417 circuit.

The KT88 and 6550 can be directly substituted for the 8417, with one ESSENTIAL check needed. I have a base diagram for the 8417, which shows their plate internally linked to both pins 3 and 1. Andrew would need to check that the Quicksilver plate leads go only to pin 3. If so, the following pins apply for the three types:

Pin 1. no connection  
Pin 2. heater  
Pin 3. plate

Pin 4. screen  
Pin 5. grid  
Pin 6. no connection  
Pin 7. heater  
Pin 8. cathode

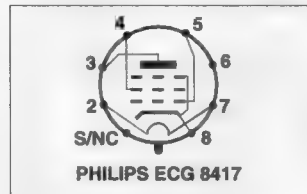
My info. on the monoblock Quicksilver is that they are 100W ultralinear amplifiers. I don't have any info. on their HT, but I suspect it would be about 450V, with a standing current of about 55ma per valve. See sketch of circuit.

If the B+ measures less than 430V, the EL34 could be substituted, provided that

pins 1 and 8 are linked. The other pins are identical.

My recommendation would be to find a decent set of

KT88s, join pins 3 and 4 together with a 100 ohm resistor, and run them as triodes (disconnect the screen taps on the output transformers). Andrew would then have 50 watts of class AB1 triode power - a real challenge to the Audio



Research Classic 60s. If the EL34s were strapped as triodes, he would get about 35W.

I hope this is useful information for Andrew, if he hasn't already had help from elsewhere.

**Andrew Neale**  
Modbury Heights,  
South Australia.

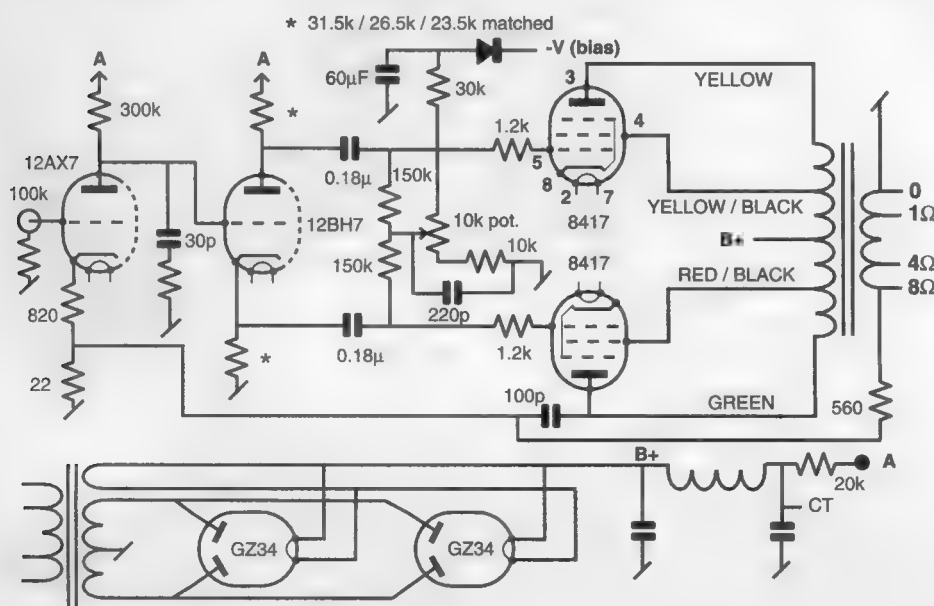
Thanks. We have reproduced your circuit from fax and hope it is correct, since some values were not clear and B+ is commonly on the output side of the choke. Our base diagram for the little mentioned 8417 comes from the Tube Substitution Handbook. Here, the plate (anode) goes to 3 alone and 1 is either an optional Screen (not an electrode) or No Connection, according to the manufacturer. **NK**

## ULTRA-LINEAR

I was most interested to discover your magazine last year as one which treats valves and vinyl seriously and I found your comments on valve amplifier design in the November supplement most interesting particularly your rejection of ultra-linear operation for your K6L6 and K5881. Following the Mullard and GEC treatises I had been brought up to think of this as the 'be all and end all' of amplifier design.

I do however have a couple of queries. Firstly much has been written on the superiority of triodes over pentodes as output devices but I have never seen any comments on their pros and cons in earlier stages of power amps or as preamps: do similar comments apply? The Mullard power amps all use pentode inputs whilst GEC go for triodes and Quad seem to have taken the GEC design and replaced two triodes with a pentode. For preamps all three use a mixture of triodes and pentodes.

In my own aged equipment all except outputs are triodes. Rogers for example in my Cadet 3 drives the output pentodes from a



QUICKSILVER AMPLIFIER (one channel)

single triode anode/cathode phase splitter with gain provided by a preceding triode voltage amplifier. In the preamp section he uses a further 3 triodes to get from the MM phono input giving 5 triodes in all per channel the first 3 being the now rare ECC807, designed specifically for this application as a superior low noise ECC83. Going further back to my state of the art domestic audio of 1950 (a KB radiogram) the output tetrodes are driven by an amplifying phase splitter using two triodes (GEC's 'floating paraphase phase inverter') preceded by a voltage amplifying triode for the detected radio signal. A fourth triode is brought into use for phono for the weaker signal from the Decca XMS variable reluctance pickups.

Neither piece of equipment uses UL output and seems to manage well enough without: QED I suppose. Indeed I imagine I would have to expend a fair amount of cash to better the musical quality of the Rogers on my preferred (classical) listening. How would your K5881 or K6L6 compare I wonder?

Secondly, I find that in general I get a more immediate, lively and atmospheric sound from LP than CD making music more involving with the former. With the Rogers I use a Goldring-Lenco GL75/Shure M75ED T2 combination and a Technics SL PG 460A CD player. Speakers are Wharfedale Lintons I 're-engined' a year or two back with Audax I" soft dome and 8" paper cone/foam surround units and 4 new element crossovers. I thought I perhaps had a bright cartridge and dull CD player but the Technics got excellent reviews and when I bought it I also auditioned the much lauded Marantz CD63 but thought that sounded rather dull and didn't like it.

Would upgrading to a

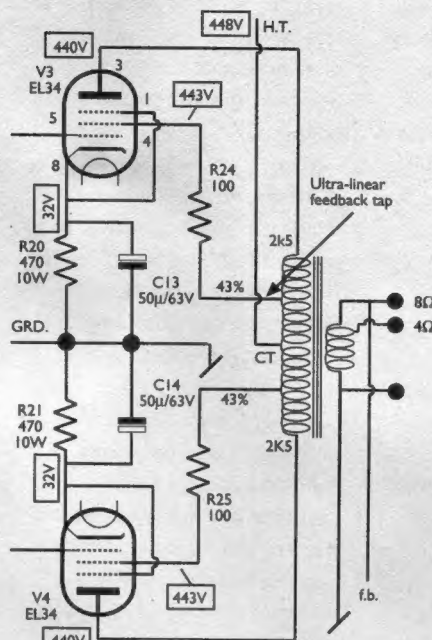
better CD player give me a more LP like sound? I suspect not and that the problem lies in the nature of the medium itself. When I have heard new DDD CDs which I also possess on the radio they have the same rather anodyne sound and yet with the odd disc the Technics shows it can provide a lively sound. Mercury 'Living Presence' CDs seem sharpest (perhaps due to their careful remastering, playing the mastertapes on the original valve recorders on which they were made). In one case where I have the same item on Mercury LP and CD the sound is virtually indistinguishable; in other cases where I have the same recording in both formats LP is always more immediate.

Finally I note that the distinguished audio panel in the magazine 'International Classical Record Collector' in their comparisons of a CD with various different LP cuts from the same master have so far always placed the CD last for audio quality. Enough said?

I would be interested in any comments you may have.

**Nicholas Coleman  
Newton-le-Willows,  
Merseyside.**

The output transformers of our K5881 amplifier have a high primary impedance, which helps keep the output stage intrinsically linear. It offers better measured performance, I found, when using the linear 6L6 valve (in rugged 5881 form) than an EL34 working in ultra-linear mode. Feedback skews an amplifier's transfer characteristic and did so when applied from a transformer with ultra-linear taps. Distortion changed in its harmonic structure as level rose. What this means is that



MULLARD 5.20 ULTRA-LINEAR OUTPUT STAGE

the pattern of distortion becomes modulated by level, not a good sign. So in my experience the complexity of ultra-linear is unnecessary; better basic design is the answer.

Andy Grove is happy with it though. He says "I have found that ultra-linear does seem to work, electrically at least. It makes a pentode operate halfway towards a triode and produces more even order distortion. Of course, ultra-linear is not the same as true triode but it offers efficiency in between pentode and triode. There

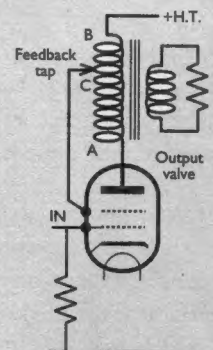
are problems with ultra-linear in that unless the output transformer is very special the screen tap will not be coupled to the anode at high frequencies and instability results. This made the old designers put caps and resistors all round the transformer to stop oscillation. Also, the commonly used 43% is not correct for every operating condition or valve. The tapping point has to be designed in."

Running the K5881 output stage 'straight', with the 5881 screens just a few volts below the anode produces just a small amount of second harmonic distortion, an innocuous characteristic. However, this is specific to the 5881 valve, which draws little grid current due to the electrode alignments. Generally, the advice is to run the anode of a tetrode at as high a voltage as possible and the screen at half anode volts, from a 'stiff' supply (i.e. one that is regulated). The ideal is postulated as a 50% tap on

#### ULTRA-LINEAR OPERATION from AMPLIFIERS AND SUPERLATIVES by D.T.N. Williamson and P.J. Walker.

If the tap is affixed to point A, giving a coupling factor of unity, the stage behaves as a triode, if at B as a simple tetrode. If now the screen is tapped at intervals between point B and point A there will be a progressive inclusion of the load impedance in the screen circuit and a progressive change from tetrode characteristics at B to triode characteristics at A.

In the case of the single valve there would appear to be little gained from this circuitry. With push-pull the reduction in distortion is greater than the reduction in gain, because of the cancellation of second harmonics. This "something for nothing" is small, however, and can be lost or even reversed if there are any appreciable departures from precise balance at any frequency.



BASIC ULTRA-LINEAR CIRCUIT



the mains transformer secondary, regulated to keep within the screen voltage rating - often 300V or so. A common approach is to use a potential divider to establish this voltage. Such an approach maximises power output and keeps screen current down.

However, I have to say that with K5881 this approach was tried and did not work, reducing power and increasing distortion, showing that much depends upon individual circumstances and components.

Recently, I reduced feedback in K5881 as far as possible (to 18dB) consistent with an upper bandwidth limit (-1dB) of 20kHz. This has helped open up the sound, improving depth perspectives in particular.

It's probably best to say that CD and LP are just 'different'. By and large, cheap CD players do a better job than cheap record decks, as well as being more convenient of course. The situation changes as price goes up, because CD is performance limited by its old 1970s digital coding system, whilst LP, being analogue, is not. So the more money you throw at it, the better it gets. **NK**

#### Andy Groves says -

There are four fundamental differences between triodes and pentodes;

1. For a given transconductance a pentode will generally give higher gain than a triode due to its much greater internal impedance.
2. The positive potential on the screen grid allows a pentode to sink more current at low voltages than a similar triode, this equates to higher efficiency in output stages.
3. For a given transconductance a pentode

will create more noise than a triode due to the random distribution of currents between the anode and grid screen.

4. Pentodes are easier to drive at high frequencies, in a triode the Miller Effect loads the input capacitively at HF, but the screen grid in the pentode prevents this.

There is possibly a fifth and that is that pentodes tend to produce a more complex harmonic distortion pattern than triodes, but it does depend on how the pentode is being used. In output stages pentodes do usually produce higher order harmonics than triodes. So the pentode is more efficient power wise, has higher gain and is easier to drive at high frequencies thereby making wide bandwidth more easily achievable. The triode however is quieter and generates simple low order harmonic distortion and its low impedance helps with speaker damping. These criteria are important for audio quality amplifiers and for the best amps triodes are usually chosen throughout.

In output stages one would ideally want the high efficiency of the pentode and the low distortion of the triode. There have been several attempts at achieving this performance and Ultra-Linear was one of them. To make a pentode operate as a pure pentode the screen grid is held at a rigidly fixed voltage. If however the screen grid is connected to the anode, the pentode starts to operate like a triode. Engineers thought that if they could connect the screen to a voltage which was somewhere in between they might get some of the advantages of both the triode and pentode. They connected the screen grid to a tap on the output transformer so that a percentage of the anode swing was fed into the screen

grid. A 43% tap (a commonly used value) feeds 43% of the anode voltage swing into the screen grid. They found that it was possible to make a mutant hybrid of pentode and triode which gave good efficiency like the pentode but which also gave more even-order distortions which would hopefully be cancelled by the push-pull operation.

Unfortunately, they soon discovered that just bringing out an extra wire part along the main primary winding caused stability problems and so resorted to adding extra components around the output transformer or making very complex windings. It seems that Ultra-Linear fell from grace due to it being a bit of a pain in the butt. **AG**

#### DIPOLE DYNAMICS

Your article on the equalised dipole subwoofer was extremely interesting, since I have been working on this very topic for almost two years now.

I substituted your equalisation circuit for my own, which incidentally had the same equalisation minus the 140Hz peak. The benefits were immediately noticeable - much improved transients and a feeling of increased speed at low frequencies.

Increasing the peak slightly to 3dB improved things even further, although there was an increasing need to move the dipoles even further away from the rear walls due to an excitation of room/boundary at 140 Hz.

It may have been due to my hurried construction but I could not achieve stability with the subsonic stage and had greater success with the circuit below, which I modelled on my own PC

I did find that I much preferred (on my dipoles) no

subsonic filter at all. You say that you feel it adds to the subjective speed at LF. I must confess I cannot detect this. However, for those using vinyl it will be necessary to prevent excessive cone movement.

Yes, without the filter there is tremendous presence of low frequency energy which is readily felt, particularly on organ and bass synthesiser.

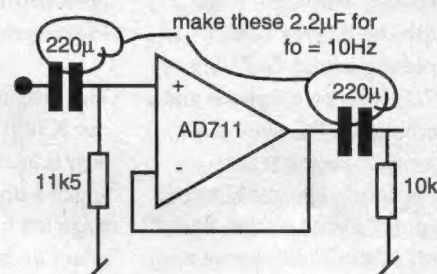
Hope this is of interest to you.

**David Huckle  
Cambridge.**

We're always glad to hear of people achieving success with interesting and advanced acoustic techniques beyond the understanding of the general hi-fi business. Proves how strong DIY can be.

I never encountered instability in the crossover, even when tuning in outrageous peaks, but layout and power supply decoupling (especially) do need to be attended to carefully.

Cone excursion is a problem with a dipole trying to produce high level subsonics and for safety, as well as for LP warps, I gravitated toward using a second order high pass filter at 20Hz, forsaking the delights of experiencing structural re-assembly of the



brickwork around the listening room.

Your circuit comprises two passive high pass sections with the op. amp. acting as a non-inverting stage between them. The right capacitor value is 2.2µF for a 10Hz turnover frequency, not 220µF. **NK**





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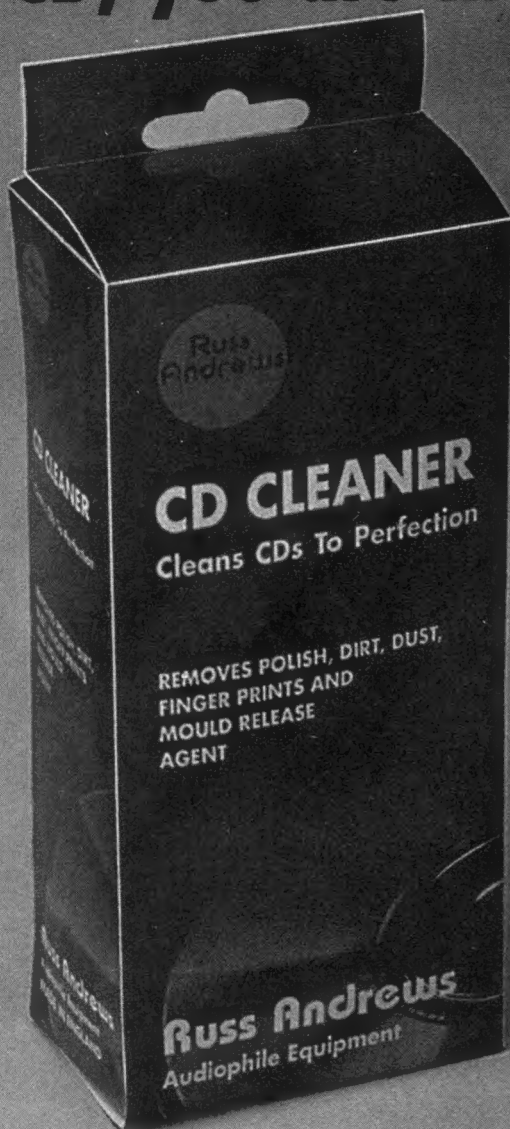
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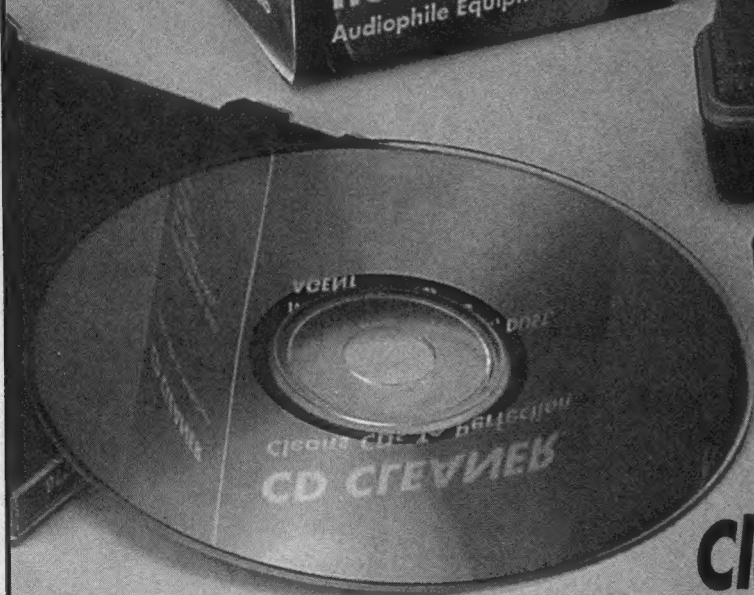
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